

# ACRP

REPORT 106

## **Being Prepared for IROPS: A Business-Planning and Decision-Making Approach**

AIRPORT  
COOPERATIVE  
RESEARCH  
PROGRAM

Sponsored by  
the Federal  
Aviation  
Administration

TRANSPORTATION RESEARCH BOARD  
OF THE NATIONAL ACADEMIES

**AIRPORT COOPERATIVE RESEARCH PROGRAM**

---

**ACRP REPORT 106**

---

**Being Prepared for IROPS:  
A Business-Planning  
and Decision-Making Approach**

**Joakim Karlsson  
Kevin King  
Rohit Viswanathan  
Timothy McInerney  
Douglas Slocum**  
MCR FEDERAL, LLC  
Washington, DC

AND

**Jessica Domitrovich  
Tim Phillips  
Jay Bingham**  
CRITICAL PATH, INC.  
West Fargo, ND

*Subscriber Categories*

Aviation • Finance • Operations and Traffic Management

---

Research sponsored by the Federal Aviation Administration

---

**TRANSPORTATION RESEARCH BOARD**

WASHINGTON, D.C.  
2014  
[www.TRB.org](http://www.TRB.org)

## AIRPORT COOPERATIVE RESEARCH PROGRAM

Airports are vital national resources. They serve a key role in transportation of people and goods and in regional, national, and international commerce. They are where the nation's aviation system connects with other modes of transportation and where federal responsibility for managing and regulating air traffic operations intersects with the role of state and local governments that own and operate most airports. Research is necessary to solve common operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the airport industry. The Airport Cooperative Research Program (ACRP) serves as one of the principal means by which the airport industry can develop innovative near-term solutions to meet demands placed on it.

The need for ACRP was identified in *TRB Special Report 272: Airport Research Needs: Cooperative Solutions* in 2003, based on a study sponsored by the Federal Aviation Administration (FAA). The ACRP carries out applied research on problems that are shared by airport operating agencies and are not being adequately addressed by existing federal research programs. It is modeled after the successful National Cooperative Highway Research Program and Transit Cooperative Research Program. The ACRP undertakes research and other technical activities in a variety of airport subject areas, including design, construction, maintenance, operations, safety, security, policy, planning, human resources, and administration. The ACRP provides a forum where airport operators can cooperatively address common operational problems.

The ACRP was authorized in December 2003 as part of the Vision 100-Century of Aviation Reauthorization Act. The primary participants in the ACRP are (1) an independent governing board, the ACRP Oversight Committee (AOC), appointed by the Secretary of the U.S. Department of Transportation with representation from airport operating agencies, other stakeholders, and relevant industry organizations such as the Airports Council International-North America (ACI-NA), the American Association of Airport Executives (AAAE), the National Association of State Aviation Officials (NASAO), Airlines for America (A4A), and the Airport Consultants Council (ACC) as vital links to the airport community; (2) the TRB as program manager and secretariat for the governing board; and (3) the FAA as program sponsor. In October 2005, the FAA executed a contract with the National Academies formally initiating the program.

The ACRP benefits from the cooperation and participation of airport professionals, air carriers, shippers, state and local government officials, equipment and service suppliers, other airport users, and research organizations. Each of these participants has different interests and responsibilities, and each is an integral part of this cooperative research effort.

Research problem statements for the ACRP are solicited periodically but may be submitted to the TRB by anyone at any time. It is the responsibility of the AOC to formulate the research program by identifying the highest priority projects and defining funding levels and expected products.

Once selected, each ACRP project is assigned to an expert panel, appointed by the TRB. Panels include experienced practitioners and research specialists; heavy emphasis is placed on including airport professionals, the intended users of the research products. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, ACRP project panels serve voluntarily without compensation.

Primary emphasis is placed on disseminating ACRP results to the intended end-users of the research: airport operating agencies, service providers, and suppliers. The ACRP produces a series of research reports for use by airport operators, local agencies, the FAA, and other interested parties, and industry associations may arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by airport-industry practitioners.

## ACRP REPORT 106

Project 10-14

ISSN 1935-9802

ISBN 978-0-309-28384-7

Library of Congress Control Number 2014931996

© 2014 National Academy of Sciences. All rights reserved.

### COPYRIGHT INFORMATION

Authors herein are responsible for the authenticity of their materials and for obtaining written permissions from publishers or persons who own the copyright to any previously published or copyrighted material used herein.

Cooperative Research Programs (CRP) grants permission to reproduce material in this publication for classroom and not-for-profit purposes. Permission is given with the understanding that none of the material will be used to imply TRB or FAA endorsement of a particular product, method, or practice. It is expected that those reproducing the material in this document for educational and not-for-profit uses will give appropriate acknowledgment of the source of any reprinted or reproduced material. For other uses of the material, request permission from CRP.

### NOTICE

The project that is the subject of this report was a part of the Airport Cooperative Research Program, conducted by the Transportation Research Board with the approval of the Governing Board of the National Research Council.

The members of the technical panel selected to monitor this project and to review this report were chosen for their special competencies and with regard for appropriate balance. The report was reviewed by the technical panel and accepted for publication according to procedures established and overseen by the Transportation Research Board and approved by the Governing Board of the National Research Council.

The opinions and conclusions expressed or implied in this report are those of the researchers who performed the research and are not necessarily those of the Transportation Research Board, the National Research Council, or the program sponsors.

The Transportation Research Board of the National Academies, the National Research Council, and the sponsors of the Airport Cooperative Research Program do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of the report.

*Published reports of the*

### AIRPORT COOPERATIVE RESEARCH PROGRAM

*are available from:*

Transportation Research Board  
Business Office  
500 Fifth Street, NW  
Washington, DC 20001

*and can be ordered through the Internet at*

<http://www.national-academies.org/trb/bookstore>

Printed in the United States of America

# THE NATIONAL ACADEMIES

## *Advisers to the Nation on Science, Engineering, and Medicine*

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. On the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Ralph J. Cicerone is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. C. D. Mote, Jr., is president of the National Academy of Engineering.

The **Institute of Medicine** was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, on its own initiative, to identify issues of medical care, research, and education. Dr. Harvey V. Fineberg is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Ralph J. Cicerone and Dr. C. D. Mote, Jr., are chair and vice chair, respectively, of the National Research Council.

The **Transportation Research Board** is one of six major divisions of the National Research Council. The mission of the Transportation Research Board is to provide leadership in transportation innovation and progress through research and information exchange, conducted within a setting that is objective, interdisciplinary, and multimodal. The Board's varied activities annually engage about 7,000 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest. The program is supported by state transportation departments, federal agencies including the component administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation. **[www.TRB.org](http://www.TRB.org)**

**[www.national-academies.org](http://www.national-academies.org)**

# COOPERATIVE RESEARCH PROGRAMS

## CRP STAFF FOR ACRP REPORT 106

**Christopher W. Jenks**, *Director, Cooperative Research Programs*

**Michael R. Salamone**, *ACRP Manager*

**Theresa H. Schatz**, *Senior Program Officer*

**Terri Baker**, *Senior Program Assistant*

**Eileen P. Delaney**, *Director of Publications*

**Sharon Lamberton**, *Assistant Editor*

## ACRP PROJECT 10-14 PANEL

### Field of Operations

**Frederick Busch**, *Denver International Airport (Retired), Denver, CO (Chair)*

**John DeCoster**, *Trillion Aviation LLC, Austin, TX*

**Al N. Gulamali**, *Lee County (FL) Port Authority, Fort Myers, FL*

**Dan J. Letellier**, *Sioux Falls Regional Airport, Sioux Falls, SD*

**F. Paul Martinez**, *Dallas/Fort Worth International Airport, Dallas, TX*

**Melinda Z. Pagliarello**, *LeighFisher, Reston, VA*

**Todd Madison**, *FAA Liaison*

**Christine Gerencher**, *TRB Liaison*

## AUTHOR ACKNOWLEDGMENTS

The research reported herein was performed under ACRP Project 10-14 by MCR Federal, LLC, and its subcontractor Critical Path, Inc. Joakim Karlsson of MCR Federal, LLC, was the Principal Investigator. The other authors of this report were Kevin King, Rohit Viswanathan, Timothy McInerney, and Doug Slocum of MCR Federal, LLC, and Jessica Domitrovich, Tim Phillips, AAE, and Jay Bingham, CPA, of Critical Path, Inc.



## FOREWORD

By Theresia H. Schatz

Staff Officer

Transportation Research Board

*ACRP Report 106: Being Prepared for IROPS: A Business-Planning and Decision-Making Approach* provides a guidebook with a decision-making process for airport management to use in justifying airport planning and funding decisions (capital and O&M) related to supporting IROPS contingency planning. This decision-making process includes the principal stakeholders involved: airports, airlines, and agencies (e.g., FAA, CBP, TSA, and state and local agencies) and considers the differences in airport characteristics (e.g., geographic location, use and lease agreements). Factors considered include the projected frequency of IROPS events, impacts on the airport and its stakeholders, and effectiveness of the proposed mitigation alternatives. Each potential investment is evaluated in terms of strategic challenges, user benefits, and tactical complexity. The research presents a structured approach to quantifying the lifecycle economic value of proposed IROPS mitigation alternatives through a spreadsheet-based business-planning and decision support tool. The tool is entitled the IROPS Investment Support Tool (IRIS).

Meeting customer core needs during irregular operations (IROPS) is a critical problem for airports, airlines, agencies, and other aviation service providers. While regulatory policies and industry practices continue to evolve, IROPS challenge the resiliency of the global aviation system and negatively impact customer core needs. IROPS can result from random phenomena and planned activities from either natural causes such as weather (e.g., thunderstorms, snowstorms, fog, and hurricanes) or other operational factors (e.g., air traffic directives such as ground delay programs, airport maintenance or construction activities, and security threats or alerts). Operational contingency planning guidance to support IROPS is provided in *ACRP Report 65: Guidebook for Airport IROPS Contingency Planning*, but managing IROPS needs to be integrated with mid- and long-term business planning and decision making. Current planning and investment evaluation processes do not adequately capture the benefits or costs associated with the planning for affected operations. Current practice in these areas relies principally on either generally accepted design practices handed down over time (e.g., use of peak month average day design standards) or more formalized benefit-cost or investment analyses designed around normal operating conditions. These practices are no longer a sufficient guide in valuing investment decisions intended to mitigate the impacts of IROPS. In addition, investment decisions being made in support of NextGen that positively impact operations must dovetail with planning and investment decisions related to IROPS. Thus, an enhanced strategy is needed that supports a more proactive business-planning approach for managing IROPS.

This research was conducted under ACRP Project 10-14 by MCR Federal, LLC, in association with Critical Path, Inc. As part of the research, the firms conducted a literature

review that included existing IROPS planning guidelines and individual airport tarmac delay contingency plans, and incorporated the research team's subject matter expertise and experience. They identified and categorized airports based on a number of criteria focusing on customer services, reviewed best practices, and surveyed airports to document existing business-planning practices for airports. The research team then developed a flexible business case analysis approach that merges multi-criteria decision analysis with traditional benefit-cost analysis. They also developed a spreadsheet-based business-planning and decision support tool and conducted demonstrations to test the tool at a sample of representative airports.

A separate contractor's final report, which provides background on the research conducted in support of the guidebook, has been posted on the ACRP Project 10-14 web page that can be found by searching the TRB website ([www.trb.org](http://www.trb.org)) for *ACRP Report 106*.

# CONTENTS

1	<b>Summary</b>
4	<b>Chapter 1 Introduction</b>
4	1.1 Objective
5	1.2 How to Use This Guidebook
6	1.3 Who Can Use This Guidebook?
6	1.4 History
8	1.5 Related ACRP Projects
10	<b>Chapter 2 Business Planning for IROPS</b>
10	2.1 Definitions
11	2.2 Identifying IROPS Events and Their Impacts
13	2.3 Identifying Mitigation Initiatives
15	2.4 The IROPS Business Case Analysis
17	2.5 Limitations of Traditional Business Case Analysis
18	2.6 Cost Estimating
19	2.7 Overview of the Business Case Methodology for IROPS Business Planning
21	<b>Chapter 3 IROPS Business Planning Using Decision Analysis</b>
21	3.1 The Analytic Hierarchy Process
22	3.2 IROPS Investment Portfolio
23	3.3 IROPS Impact
24	3.4 Costs
25	3.5 Evaluating the Effectiveness of IROPS Mitigation Initiatives
29	3.6 Rank Ordering the Investment Portfolio
31	<b>Chapter 4 IROPS Investment Support (IRIS) Decision Support Tool</b>
31	4.1 Before Getting Started with IRIS
32	4.2 IRIS Workflow
33	4.2.1 Defining the IROPS Portfolio
34	4.2.2 Defining Lifecycle Costs
35	4.2.3 Determining Stakeholder Preferences Through Pairwise Comparisons
36	4.2.4 Evaluating the Effectiveness of Each IROPS Investment Initiative
36	4.2.5 Ranking the IROPS Investment Portfolio
38	<b>Chapter 5 Strategic Planning, Financing, and Airport Use Agreements</b>
38	5.1 Strategic Planning
38	5.2 Funding Eligibility
38	5.2.1 Internally Generated Funds
39	5.2.2 Airport Improvement Program/Passenger Facility Charges
40	5.3 Airport Use Agreements
41	5.4 Leased Facilities

42	5.4.1 Exclusive Use
42	5.4.2 Preferential Use
42	5.4.3 Common Use
42	5.4.4 Limitations and Opportunities
42	5.5 Rates and Charges
43	5.6 Majority-In-Interest
<b>44</b>	<b>Chapter 6 Lessons Learned</b>
44	6.1 IROPS Business-Planning Needs
45	6.2 Impact of Funding Availability
46	6.3 Need for an IROPS Investment Decision Support Tool
47	6.4 Implementing Pairwise Comparisons
48	6.5 Evaluating Non-Economic Benefits
48	6.6 Conclusions
<b>50</b>	<b>References</b>
<b>A-1</b>	<b>Appendix A Business Case Analysis Primer</b>
<b>B-1</b>	<b>Appendix B IRIS User Guide</b>
<b>C-1</b>	<b>Appendix C Sample IROPS Investment Portfolio</b>

---

Note: Many of the photographs, figures, and tables in this report have been converted from color to grayscale for printing. The electronic version of the report (posted on the Web at [www.trb.org](http://www.trb.org)) retains the color versions.

## SUMMARY

# Being Prepared for IROPS: A Business-Planning and Decision-Making Approach

This guidebook presents a business-planning approach that can be used to prioritize the funding of airport improvements designed to mitigate the disruptive impacts of irregular operations (IROPS). The guidebook describes the principles of business case analysis and provides practical guidance on how to implement an approach based on decision theory. This approach uses the analytic hierarchy process (AHP) methodology to evaluate the effectiveness of the proposed improvements. Instead of assigning monetary values to benefits and costs, as is the case in traditional benefit-cost analyses, this approach combines subjective evaluation with metrics used in traditional business case analysis.

The guidebook comes with a CD-ROM that contains an accompanying decision support tool called IRIS (for IROPS Investment Support). Created with Microsoft Excel, this tool can be used by airports to implement the proposed business-planning approach and supports the evaluation of a maximum of five IROPS events with up to five mitigations each. The tool is designed for use at a broad range of airports, from general aviation airports to large hubs. Use of the IRIS decision support tool requires no formal training in AHP or business planning, and it requires no software other than Microsoft Excel.

## Background

IROPS events can have a substantial impact on airport operations and the orderly flow of passengers and freight through the air transportation system. Recent regulatory attention on IROPS has resulted in requirements for the development of contingency plans for extended tarmac delays. An established and growing body of best practices exists for operational preparedness for IROPS; however, no literature addresses how to evaluate investments in IROPS-related mitigation initiatives.

Traditional business-planning methods, notably the benefit-cost analysis, provide established methods for determining the economic value of proposed airport improvements. The existing guidance on airport business case analysis focuses on capacity projects, however, and may not be suitable for IROPS-related investments. Additional reasons why a new approach is needed include the following:

- Conducting a benefit-cost analysis for an IROPS mitigation initiative is labor intensive, especially if several possible IROPS events must be considered.
- Quantifying benefits is difficult, given that IROPS events are associated with an unusually high level of uncertainty.
- Not all benefits of IROPS mitigation initiatives can be expressed in monetary values, which is a requirement for computing a benefit-cost ratio.

## 2 Being Prepared for IROPS: A Business-Planning and Decision-Making Approach

- Airport activity metrics used for benefit-cost analyses focus on the use of averages, which may not capture the volatility in activity during IROPS events.

### Approach

The proposed decision-making approach is conceptually similar to the benefit-cost analysis in that the approach quantifies benefits and compares the resulting values against lifecycle costs. In the approach presented in this guidebook, however, benefits are not expressed in monetary terms. Instead, they are computed as a function of the likelihood of the associated IROPS event, the potential severity of the disruptive impacts, and the effectiveness of the proposed mitigation. The effectiveness, in turn, is evaluated using AHP—a method that provides a structured path for incorporating subjective evaluations. The objective of AHP is to elicit the stakeholders’ true preferences, avoiding some of the weaknesses normally associated with using subjective input.

The proposed decision-making approach presents a hierarchy of evaluation criteria to the user for assessment. The hierarchy consists of criteria grouped into three categories: strategic challenges, user benefits, and tactical complexity. Using pairwise comparisons, the stakeholders’ priorities among these competing criteria are determined and quantified as weights. The individual criteria are then evaluated subjectively using five-step scales. The results from this evaluation are combined with the weights from the pairwise comparisons to compute an overall effectiveness score for each mitigation initiative.

The proposed methodology has several advantages. It allows for the quantification of intangible benefits that are normally difficult or impossible to monetize using traditional methods. The approach combines subjective evaluations that draw on the expertise of the airport staff with objective, quantitative measures such as lifecycle cost. The use of pairwise comparisons reduces the bias that is otherwise possible when relying on subjective evaluations. The use of pairwise comparisons also increases differentiation in the evaluation of the effectiveness criteria, which improves the quality of the results.

### Decision Support Tool

The business-planning methodology described in this guidebook has been implemented in the IRIS decision support tool. The IRIS decision support tool is a stand-alone software module developed for use in Microsoft Excel. The IRIS user interface presents a visual map that guides the user through a series of wizards, one for each step in the process. This map creates a structured path through the input requirements. IRIS is designed for users without any background in business planning. The tool includes support for “What if?” analysis, and for saving, exporting, and printing the results and associated input tables. Explanations of the required inputs are provided in the software and are described in more detail in the IRIS User Guide (Appendix B).

The main output of the IRIS decision support tool is a summary report that lists the mitigation initiatives in rank order from highest to lowest value. This table can be used to prioritize the airport’s use of funding intended to mitigate IROPS events. The summary report contains the scores used to determine the ranking, including the benefit score and its subcomponents; the impact and effectiveness scores; and a cost score computed from the lifecycle costs. Separate tables document the inputs provided by the user. These tables can be used as back-up material to help justify the investment recommendations made with the assistance of the decision support tool.

## Findings

An airport outreach effort was conducted as part of ACRP Project 10-14. This effort consisted of a broad-based airport survey, structured interviews, and a demonstration project to validate the decision support tool. The survey responses indicated that the majority of airports do not have a formal process for IROPS-related business planning. The responses also confirmed that airports perceive a need for a business case analysis methodology for IROPS-related investments, although the perceived need varied by airport size. Larger airports expressed a stronger need for formal business-planning processes for IROPS investments than did smaller airports. More than two-thirds of airports indicated a need for a decision support tool to support their IROPS investment analysis.

In the demonstration project, four airports were selected as participants, representing a range of geographic location and airport size. Individual familiarization sessions were held with each airport. The airports then used IRIS during the demonstration period, exploring both a structured example and business cases of their own choosing. A formal assessment instrument was used to evaluate the features, usability, and effectiveness of IRIS. Three airports completed the demonstration project and submitted completed assessment instruments. A fourth airport participated in the demonstration but was unable to complete it within schedule because of resource constraints. Although the number of participating airports was small, there was unanimous agreement among the participants that IRIS was effective in meeting the airports' IROPS business-planning needs and that they likely would use the tool.

Feedback from the demonstration project and internal testing were used to make changes to IRIS with a focus on enhancing usability. The use of pairwise comparisons represented a particular challenge to implementation in IRIS. The inputs from the pairwise comparisons must be logically consistent; otherwise, an error is generated. IRIS includes a validation process that checks for logical consistency, but manually identifying and correcting the comparisons occasionally proved difficult for the user. To solve this challenge, an optional feature was added that, in the case of an error, enables the user to elect to have the user inputs adjusted using an iterative process that eliminates any logical inconsistencies. The threshold for validating logical consistency was also relaxed slightly to reduce the likelihood of the error occurring.

This project is only a first step in providing best practices and tools for business planning for IROPS, but it has resulted in several significant findings. These findings include the following:

- An accepted body of knowledge supports the operational preparedness required to handle IROPS events, but almost no literature exists on business planning for related mitigation initiatives.
- A confirmed need exists for business-planning methods to support investment decisions related to IROPS mitigations.
- The use of decision theory allows for rapid and effective assessments of the value of IROPS mitigation initiatives by combining subjective evaluations with objective business case analysis metrics.
- The proposed business-planning methodology allows for the estimation of benefits under high levels of uncertainty and supports the quantification of intangible benefits.
- Pairwise comparisons can be used to reduce biases and increase differentiation between evaluation criteria but can lead to implementation challenges that must be addressed.



## CHAPTER 1

# Introduction

### 1.1 Objective

The objective of ACRP Project 10-14 was to develop and test an analytical approach and software tool to evaluate the value of projects that airports might fund to reduce the disruptive impact of irregular operations (IROPS). For the purpose of this study, the term IROPS was used to describe exceptional events that result in operational conditions beyond the airport's normal planning activities and capabilities. The study resulted in this guidebook to understanding business planning for mitigating IROPS events and an accompanying decision support tool—the IROPS Investment Support (IRIS) Tool, an application for use in Microsoft Excel.

The guidebook and the IRIS decision support tool were developed to help airport operators and others to understand the business case for funding airport improvements intended to mitigate IROPS events. In particular, IRIS helps prioritize airport funding across different mitigation initiatives addressing the impacts of one or more types of IROPS events. The tool is designed to be applicable to the widest possible range of airports, including general aviation, non-hub, small hub, medium hub, and large hub facilities.

Although delays and emergencies have challenged airports since the development of modern air transportation, the issue of more disruptive IROPS events has risen to the forefront during the last 5 to 10 years. Reasons for increasingly disruptive IROPS events include increasing passenger load factors, frequency of disruptive weather events, the high level of connectivity in the U.S. National Airspace System, and growing public, media, and political attention, particularly as applied to extended tarmac delays, which have also been the focus of the regulatory response.

The U.S.DOT has reacted to the potential of IROPS events to severely disrupt airport operations and passenger itineraries. In particular, rules have been published that direct airlines and airports to plan for and prepare for extended tarmac delays. These rules require the preparation of contingency plans and enable the U.S.DOT to impose fines on airlines. In the airport and research communities, focus has been placed on providing information and tools for airports to plan and prepare for the risks associated with IROPS.

The research presented in this guidebook represents a continuation of the emerging body of knowledge addressing planning for IROPS. Whereas the focus of previously completed research has been on operation, planning, and risk management, a missing component has been business case analysis—determining the economic value of investments in airport improvements that mitigate the impact of IROPS. Given the scarcity of airport funding and that there are a number of possible IROPS events an airport can face, a business-planning approach is needed to prioritize alternatives prior to committing funds.

This guidebook presents a decision analysis approach that can be used to rapidly evaluate mitigation initiatives across a wide range of criteria. The approach is implemented in the IRIS

decision support tool. IRIS is intended to help airports prepare business case analyses in support of IROPS investment decisions. The approach combines business-planning principles with the planning and operational expertise of the airport's management and operational teams. It does so by taking into account preferences and constraints of the airport and its stakeholders. The main output of IRIS is a ranked list of IROPS mitigation initiatives, with quantitative scores assessing impact, benefit, cost, and overall economic value.

## 1.2 How to Use This Guidebook

The guidebook is designed to provide a practical approach for prioritizing funding decisions related to mitigating the impacts of IROPS events. The guidebook contains the following information:

1. Background material on business planning for IROPS that is intended to expand the reader's knowledge base. The guidebook describes the analytical approach and how it was implemented in IRIS. This material is intended for the reader who wants to understand the methodology used by IRIS to have a deeper understanding of the model results.
2. The IRIS User Guide, a comprehensive reference that describes the features of IRIS and provides instructions for its use. The User Guide describes how to get started, the features of the user interface, the inputs required to perform an IROPS business case analysis, and the output tables (see Appendix B).

The material in the guidebook is organized to provide a logical path leading up to the use of IRIS to support IROPS-related investment decisions. This guidebook is organized as follows:

- Chapter 1 provides an overview of the guidebook, objectives, information for the reader, and background material on the history of IROPS events and related research projects.
- Chapter 2 covers the fundamentals of business planning for IROPS mitigations that an airport might consider funding. This chapter defines key terms that are used throughout the guidebook. It also describes how the alternative approach for IROPS investment planning presented in this guidebook augments traditional business case analysis techniques.
- Chapter 3 provides detailed information on the business-planning and decision-making approach that was adapted for this project. This chapter includes an introduction to the analytic hierarchy process (AHP) methodology used in the accompanying decision support tool.
- Chapter 4 is a guide to IRIS, the decision support tool that implements the business-planning approach selected for IROPS investment planning. This chapter describes how to define a portfolio of IROPS investment initiatives to be evaluated, what information should be collected by the airport prior to using the tool, how this Microsoft Excel-based tool should be used, and how to interpret the results. It also describes limitations of the tool that should be understood prior to using the results.
- Chapter 5 describes the relationships between business planning for IROPS initiatives and airport strategic planning and financing, as well as potential interactions with airport use agreements.
- Chapter 6 summarizes lessons learned, drawing both on internal findings from the ACRP research project and results from an external airport demonstration project. Recommendations for future work also are included in this chapter.

Where appropriate, reference material has been placed in appendixes. Appendix A contains a primer on traditional business case analysis techniques. Appendix B contains the IRIS User Guide. Appendix C contains a sample IROPS investment portfolio that can be used for training and testing purposes.

Notice that full understanding of the material in this guidebook is not necessary for the purpose of using IRIS. The information provided is intended to explain the selected decision

## 6 Being Prepared for IROPS: A Business-Planning and Decision-Making Approach

analysis approach and how it is implemented in IRIS. It provides background material to help the user understand the inner workings of IRIS and be able to explain the results. For readers who are interested in quickly getting started with IRIS, the following sections of this guidebook are recommended:

- Section 2.1 Definitions
- Section 2.3 Identifying Mitigation Initiatives
- Section 2.7 Overview of the Business Case Methodology for IROPS Business Planning
- IRIS User Guide (Appendix B)

### 1.3 Who Can Use This Guidebook?

This guidebook can be used by all airports that are considering acquisitions or construction projects with the purpose of mitigating IROPS events. The only requirement is that each investment option be associated with a cost. Costs can include soft costs, such as the value of the labor hours used by an airport's own staff to prepare a mutual assistance plan. The focus of the business-planning approach is on airports with passenger operations. This focus mirrors the regulatory focus of the U.S.DOT, which has centered on mitigating extended tarmac delays affecting domestic and international passengers; however, the approach and the accompanying decision support tool are not limited to passenger applications.

When developing an IROPS business plan, it will be useful to have participation and input from a broad range of functional areas at the airport. The areas of responsibilities that should be represented include:

- **Management:** Executive leadership, policy, and overall compliance with airport mission.
- **Operations:** Operational and certification requirements, efficiency, and safety.
- **Emergency Response/Law Enforcement:** Operational and certification requirements, safety, and security.
- **Planning:** Capital improvement planning, funding, and land use compatibility.
- **Finance:** Finance, funding, and airport use agreements.

At larger airports, these functional areas may be represented by separate individuals. Conversely, at a general aviation airport, the airport manager may be solely responsible for all functions. Because the decision-making approach and support tool also take into account impacts on passengers and airlines, it may be valuable to also seek tenant input into the decision-making process.

The guidebook and accompanying decision support tool can also be used by decision makers and planners at regional, state, and federal agencies with oversight over the operation, management, and funding of airports. For example, state aviation planners can use the tool to compare projects proposed at different airports. The board of an airport authority may use the output of the tool to review and prioritize funding requests submitted by the airport management team.

The decision support tool requires certain hardware and software to be available. These include a computer with an optical disc drive or Internet connection (to install or download IRIS) and Microsoft Excel (version 2007 or later).

### 1.4 History

IROPS events are not a new phenomenon, but over the last few years they have received increased attention from the media, policy makers, operators, and the research community. Table 1 contains a sample of seminal and typical IROPS events that have affected U.S. airports

**Table 1. Historical IROPS events.**

<b>Airport</b>	<b>Date (Start)</b>	<b>Description</b>
Bradley International Airport	10/29/2011	Poor weather forecasting, a heavy early winter snowstorm and a planned Instrument Landing System maintenance shutdown resulted in four aircraft diversions from the New York City airports to Bradley International Airport. The aircrafts/passengers experienced 7- to 10-hour tarmac delays at Bradley. The delays were attributed to lack of gate space because of previous diversions, snow-contaminated apron, intermittent power outages, and lack of Federal Inspection Services personnel and facilities to process international diversions.
Midway Airport	4/27/2012	While in flight, a woman returning from a trip to Uganda told her mother of bites she suffered during her trip along with contact with a sick child. The mother called the local hospital for guidance on treating her daughter's symptoms. The hospital informed the Centers for Disease Control and Prevention because of the possibility of infectious disease and the woman's travel to a tropical country. Health officials boarded the aircraft at Midway Airport when it landed. The flight was quarantined on the tarmac for 3 hours until the woman and the rest of the passengers were cleared.
Seattle-Tacoma (Sea-Tac) International Airport	2/28/2001	At 10:55 a.m. a magnitude 6.8 earthquake struck Western Washington State. Sea-Tac Airport was immediately closed after the earthquake because of extensive damage to the Air Traffic Control Tower (ATCT). The tower had been constructed circa 1970 atop a building dated to the 1940s. Sufficient damage occurred to sever the welded connections at the base of the steel columns supporting the tower roof. The glass in the tower failed and the ceiling collapsed. The airport reopened the next evening using a portable control facility, and a new ATCT has since been built using modern seismic standards.
King County International Airport/Boeing Field	2/28/2001	An earthquake caused minor structural and nonstructural damage to the ATCT. Soil liquefaction and lateral spreading caused gaps in the runway pavement resulting in the closure of the airport for 1 week.
Denver International Airport	12/20/2006	Back-to-back snowstorms deposited an initial 24 inches of snow followed by an additional 9 inches approximately 3 days later. On top of the record snowfall, the airport and surrounding areas experienced ground blizzard conditions reducing visibilities to levels below operational minimums, closing the airport. During the closure, crews were pulled from the airfield to assure their personal safety. When it became possible for crews to resume their work, it took approximately 22 hours for the snow drifts to be cleared sufficiently to resume aircraft operations.
Los Angeles International Airport	11/30/2011	High winds in the Los Angeles area caused a temporary power outage at Los Angeles International Airport and the closure of one runway due to debris. At least 20 inbound flights were diverted and flights were delayed.
Detroit Metropolitan Wayne County Airport	1/2/1999	A snowstorm stranded hundreds of passengers on Northwest Airlines aircraft, which were queued on taxiways for up to 8 hours. The delays and cancellations were most severe for Northwest Airlines because the airport is a connecting hub for that carrier. As the storm increased in intensity, departing flights experienced ground delays because of snow accumulation and the deicing crews' inability to treat aircraft. Aircraft were forced to return to the terminal as gates became available. Weather conditions made it unsafe for ground personnel to properly move aircraft to hangars or remote parking areas, which prevented gates from opening to unload stranded passengers. The next day, aircraft could not be moved until the aprons and taxiways could be plowed. Passengers reported lack of food and beverages, as well as full lavatory tanks.

*(continued on next page)*

## 8 Being Prepared for IROPS: A Business-Planning and Decision-Making Approach

**Table 1. (Continued).**

<b>Airport</b>	<b>Date (Start)</b>	<b>Description</b>
Ted Stevens Anchorage International Airport (ANC)	3/22/2009	Alaska's Mount Redoubt volcano erupted several times over the course of a week in late March 2009, ejecting ash into the air near Anchorage, Alaska. ANC was closed for 1 day because of the ash falling in the area. Alaska Airlines had limited flights to and from ANC for a couple of days during the red alert level, then canceled all flights to and from ANC on Thursday, March 26, 2009 after an eruption earlier in the day sent an ash cloud 65,000 feet high. Alaska Airlines had canceled more than 250 flights since March 22, affecting more than 10,000 passengers at airports in Seattle, Phoenix and Anchorage.
Sea-Tac International Airport	3/22/2009	Eruptions of Alaska's Mount Redoubt volcano resulted in the diversion of numerous international/domestic cargo flights from Anchorage to Sea-Tac International Airport. According to airport officials, Sea-Tac received at least three times the normal arrivals of international cargo planes.
Airports Nationwide	Since 2001	According to reports from the Department of Homeland Security, airport security breaches have occurred, on average, seven times a day since 2001. Security breaches range from momentary loss of security to incidents that require terminals to be cleared and all passengers re-screened. These disruptions delay operations from a few minutes to several hours.

since 1999. The list is not meant to be exhaustive; rather, it demonstrates the range and nature of IROPS events. Notice that the table highlights several events that were widely reported in the media because of their extreme nature; however, airports also face IROPS events that have a less severe impact.

Much of the initial focus on IROPS has been on extended tarmac delays and their impact on passengers. By 2012, federal rules were in place to protect passengers subjected to extended delays on both domestic and international flights (U.S.DOT 2012a). These rules require carriers to prepare contingency plans and give passengers the option of deplaning. They allow for substantial fines—up to \$27,500 per passenger for delays extending beyond 3 hours (4 hours for international flights). After the issuance of these rules, the number of extended tarmac delays dropped sharply, but since then the number has increased somewhat (Trejos 2012).

The initial regulatory actions focused on air carriers, but a subsequent rule was enacted requiring airports to file tarmac delay contingency plans (U.S.DOT 2012b). The deadline for airports to file these plans was May 14, 2012. At a minimum, these plans must address the deplanement of passengers following excessive tarmac delays, the provision of shared facilities and gates during IROPS events, and the provision of a sterile area for passengers on international flights that require U.S. Customs and Border Protection (CBP) screening.

## 1.5 Related ACRP Projects

This study is one of several projects conducted within the ACRP that are intended to help airports prepare for IROPS. Because this study focuses more narrowly on preparing business case analyses for possible IROPS mitigations, it is important for airports to be familiar with the broader literature on IROPS planning. Proper planning for contingencies and prolonged disruptions is by necessity a precursor to the preparation of the business case. This emerging body of research includes the following ACRP projects and publications:

- *ACRP Report 65: Guidebook for Airport Irregular Operations (IROPS) Contingency Planning* (Nash et al. 2012), as well as a research report and Microsoft Word documents related to

ACRP Project 10-10 which airports can use as interactive tools for preparing individual IROPS plans.

- *ACRP Report 74: Application of Enterprise Risk Management at Airports* (Marsh Risk Consulting 2012). This guidebook covers risk management, which is functionally related to IROPS planning. It contains a grading scheme for evaluating risks that is a useful template for developing effectiveness ratings. The project that developed *ACRP Report 74* also developed an electronic tool, created using Microsoft Excel.
- ACRP Project 03-18, “Operational and Business Continuity Planning for Prolonged Airport Disruptions.” The objective of this project is to develop a guidebook for airport operators to plan and prepare for catastrophic events that lead to prolonged airport closure. The project is more narrowly focused than the objectives of ACRP 10-10 and focuses on continuity planning. At the time of writing, the final deliverables had been submitted and were under editorial review.
- ACRP Project 04-15, “A Tool for Developing Airport Terminal Incident Response Plans.” The objective of this research is to develop a tool to prepare and maintain incident response plans for airport terminals. Although limited to the airport landside, the resulting guidebook should help airports identify IROPS-related mitigations and initiatives. At the time of writing, this project was ongoing.

For the purpose of ACRP Project 10-14, *ACRP Report 65* is treated as the main collection of best management practices for operational planning for IROPS. Other sources were also reviewed, however, including 50 individual airport contingency plans for extended tarmac delays. The authors also coordinated with the principal investigators of ACRP projects that were ongoing at the time this guidebook was prepared.



## CHAPTER 2

# Business Planning for IROPS

This chapter provides general guidance on business planning for IROPS. It discusses basic terminology, best practices, and limitations of traditional business case analysis methodologies, such as the benefit-cost analysis.

### 2.1 Definitions

In the context of economic analysis, the terms *business planning* and *business case analysis* refer to analyzing the economic value of an investment of funds in a particular project, such as the construction of an overflow apron at a regional airport. The purpose of this analysis is to assess, in economic terms, whether the value received from this investment is outweighed by its costs. The value, usually referred to as the *benefit*, considers the air transportation system as a whole. It incorporates benefits incurred by passengers (e.g., time savings from delay reduction), airlines (e.g., fuel savings), and airports (e.g., labor cost savings). Costs generally include the total costs throughout the investment's lifecycle. These include initial acquisition costs, operations and maintenance (O&M) costs, and any required costs for mid-lifecycle technology upgrades (often called a *tech refresh*). Key business case analysis terms are defined in more detail below (Landau and Weisbrod 2009):

- **Benefit:** The net value to society of all positive aspects of a construction project, acquisition, or other program, over the course of its lifecycle. Societal benefits cover all private, federal, and other public entities affected by the project. The term usually is used to focus on the economic value of such benefits, especially those that can be quantified.
- **Cost:** The net value to society of all expenses of a project over the course of its lifecycle. Costs include capital costs, O&M costs, tech refresh costs, and any termination costs. Capital costs refer to the investment, construction, and acquisition costs associated with the initial implementation of the project.
- **Benefit-Cost Analysis:** A business case analysis that evaluates the net economic value of an investment to society, by comparing the societal benefits associated with the project to its lifecycle costs. The term is usually used to mean a quantitative comparison of the economic value of benefits to costs, but can also include qualitative aspects. Because benefit-cost analyses consider future economic value, they are inherently uncertain and therefore typically include a risk analysis. This risk adjustment expresses benefits and costs as probability distributions and can be used to quantify the uncertainty, conduct sensitivity analysis, and incorporate varying degrees of pessimism or optimism.

Because this guidebook focuses on business planning for IROPS, it is important to define, in workable terms, which events constitute IROPS events, what their impacts are, and what is meant by an IROPS mitigation. These definitions are needed to understand the research

problem and to structure the development of the business-planning approach presented in the guidebook. The following definitions are used:

- **IROPS Event:** Exceptional incidents that cause the airport to operate in off-nominal conditions that have not been planned for as part of the airport's normal certification or emergency planning. These incidents disrupt flight schedules and the normal flow of passengers through the air transportation system. They require actions or capabilities beyond those considered usual by aviation service providers. An IROPS event typically lasts from a few hours up to 48 hours.
- **IROPS Impact:** The resulting changes in operation from nominal conditions resulting from the IROPS event.
- **IROPS Mitigation:** Proposed action for lessening or eliminating the negative impact(s) of an IROPS event.

The IROPS event is the triggering incident that causes an abnormal condition not accounted for in the airport's normal planning activities. The event is the cause of the IROPS situation, whereas the IROPS impact is the consequence. An example of an IROPS event might be a severe ice storm, and an impact might be extended tarmac delays. Multiple IROPS events can lead to the same impact, and each IROPS event can have multiple impacts. Furthermore, although the **event** → **impact** → **mitigation initiative** link is an important concept for framing the research problem, the decision support tool uses only the mitigation initiative as a direct input.

Notice that the proposed definition for IROPS events focuses on passenger travel. Media, legislative, and regulatory responses have focused on disruptions to passengers, and that focus is reflected in this definition. The definition is consistent with *ACRP Report 65*, which provides tools for “commercial passenger service airports” (Nash et al. 2012, 1). The definition for IROPS used in *ACRP Report 65* reads as follows (Nash et al. 2012, 99):

**Irregular Operations (IROPS):** Exceptional events that require actions and/or capabilities beyond those considered usual by aviation service providers. Generally speaking, an impact of these events is the occurrence of passengers experiencing delays, often in unexpected locations for an undetermined amount of time. Examples include extreme weather events (such as snowstorms, hurricanes, tornados), geological events (such as earthquakes, volcanoes), and other events (such as power outages or security breaches).

This definition refers to aviation service providers in general; however, the focus of both guidebooks is on passengers, specifically those faced with extended delays. It is important to note, however, that the decision support tool is not based on a predefined set of IROPS events. The user-defined IROPS investment portfolio allows flexibility and support for the broadest possible range of IROPS events (see Chapter 4 for more detail). Clearly, IROPS have the potential to affect all aviation users, including cargo operators, general aviation, military aviation, and operators of public aircraft. As an example, Table 1 lists a March 2009 IROPS event at Seattle-Tacoma (Sea-Tac) International Airport the main impact of which was the diversion of cargo aircraft. The business-planning approach and the IRIS decision support tool provide full support for IROPS events affecting cargo or general aviation operations, even though the guidebook and examples focus on commercial passenger operations.

## 2.2 Identifying IROPS Events and Their Impacts

The definitions given in Section 2.1 were used to specify criteria for identifying IROPS events. These criteria include the following:

1. The event should be relatively rare.
2. The event should significantly impact passenger services.

## 12 Being Prepared for IROPS: A Business-Planning and Decision-Making Approach

3. The event should, at least in part, fall outside the airport's normal planning for incidents, accidents, emergencies, and severe weather.
4. The event should generally range in duration from a few hours up to 48 hours.

The third criterion reflects the broad range of planning and preparation that airports conduct to respond to emergencies and other disruptive events that occur or have occurred with sufficient frequency that they are anticipated. This planning is conducted in accordance with best industry practices, notably FAA Advisory Circular 150/5200-31C, *Airport Emergency Plan* (FAA 2010). For example, a wheel well fire would be covered in the airport's Airport Emergency Plan and the mitigations needed for an effective response (e.g., aircraft rescue and firefighting equipment) would be justified by the requirement to meet airport certification standards. Although overlap exists, planning for IROPS focuses on events that fall outside the scope of normal emergency planning and preparation.

The results of the process of identifying IROPS events are shown in Table 2. The identification of IROPS events is based on past incidents, the review of existing literature and best practices, and the research team's professional experience in airport planning and operations.

**Table 2. IROPS events.**

Event/Event Subtype	Event/Event Subtype
Severe Weather Events	Infectious Diseases
High wind	Individual carrier
Tornado	Epidemic
Hurricane/tropical cyclone	Pandemic
Heat wave	
Extreme cold	Security
Dense fog	Checkpoint security breach
Thunderstorm/heavy rain/flooding	Navigation system jamming/spoof
Electrical storm	Hijacked aircraft
Snow/blizzard	Laser attack
Damaging hail	Perimeter security breach
Ice storm	Terrorist attack
Dust storm	Unattended/suspicious luggage
Natural Disasters	
Earthquake	Construction/Mechanical
Volcanic eruption	Air conditioning failure
Landslide	Damaged cable
Dam break	Damaged pipeline
Tsunami	Heat failure
Wildfire	Power failure
Solar storm	Water line break
Man-made Disasters	
Hazardous materials release	Airline Operations
Military aircraft/ordnance issue	Flight reservation system/IT outage
Discovery of explosives	
Aircraft and Vehicle Accidents/Emergencies	Labor Disruption
Aircraft accident	Air traffic control labor disruption
Structural fire	Airline labor disruption
Access road accident	Airport labor disruption
Railway/people mover accident/ mechanical problem	Security/Federal Inspection Services labor disruption
Medical Emergency	Very Important Person (VIP)
Aircraft medical emergency	VIP/sports team arrival/departure
Terminal medical emergency	

**Table 3. IROPS impacts.**

Aircraft recalled to gate
Disrupted communications
Diverted flights to airport
Excessive queue lengths (check-in)
Excessive queue lengths (security)
Extended passenger delay (generated off-airport)
Extended passenger delay (terminal)
Extended tarmac delay
Power outage and/or utility disruptions
Quarantined aircraft/passengers
Unanticipated need for Federal Inspection Services
Unexpected closure of control tower/approach control facility
Unexpected closure of runway
Unexpected closure of terminal/concourse
Unexpected passenger surge (terminal)

To organize the list of IROPS events, a two-layered categorization scheme was employed placing sub-events within broader event categories. The identification of IROPS events was used for structuring the development of the decision support tool by taking into account the range of events that might be addressed by an IROPS-related investment; however, the list is not meant as an exclusive or complete identification of possible IROPS events.

The next step was to identify potential impacts that can be linked to the IROPS events that were identified in Table 2. The results of this step are shown in Table 3.

Specific IROPS impacts can be mapped to the causal IROPS event(s). It is important to remember that one event can have multiple impacts, and different events often lead to the same impact. Consequently, there is not a one-for-one mapping between events and impacts. Table 4 displays a notional example of mapping of IROPS events to impacts.

## 2.3 Identifying Mitigation Initiatives

As described in Section 2.1, a mitigation initiative is an alternative or option, associated with some cost, to reduce or eliminate the negative impacts of an IROPS event. IRIS uses user-defined mitigation initiatives and can incorporate virtually any investment initiative associated with

**Table 4. Notional example of mapping of IROPS events to impacts.**

IROPS Event (Cause)	IROPS Impact (Consequence)				
	Extended Passenger Delay (Terminal)	Extended Tarmac Delay	Excessive Queue Lengths (Check-in)	Excessive Queue Lengths (Security)	Passenger Surge (Terminal)
High winds	✓	✓			✓
Airline labor disruption	✓		✓		✓

a measurable lifecycle cost. A set of specific mitigation initiatives was identified in support of testing and developing the business case analysis approach. The process used to identify specific mitigation initiatives and their outcomes is described here.

In the context of ACRP Project 10-14, IROPS mitigation initiatives are categorized as either capital or O&M cost items intended to reduce the negative impacts of IROPS events. For each initiative, an initial identification is made as to whether the mitigation would represent a capital cost or O&M cost, using the following working definitions:

- **Capital:** Fixed, one-time expense for a durable good (typically equipment, buildings, or other facilities).
- **O&M:** Recurring expenses (typically labor costs, utilities, or consumables).

Categorization as a capital cost versus an O&M cost does not affect the design or functionality of the business-planning approach of IRIS. The categorization of the cost does, however, determine whether the related lifecycle costs are specified only as recurring costs (for O&M items) or as both fixed and recurring costs (for capital items).

Given this categorization, the IROPS mitigation initiatives were then selected using the following two criteria:

1. The objective of the initiative must be to mitigate the impact of IROPS that disrupt passenger services.
2. The mitigation initiative must be associated with a measurable cost that is substantial enough to justify the effort of formal business planning.

The first requirement was meant to ensure that the mitigation initiatives were selected in accordance with the definition of an IROPS event. The second requirement was necessary given that the focus of the project was on developing a quantitative approach to business planning. Initiatives that lack tangible, measurable costs necessarily fall outside the scope of this study. Initiatives with measurable but very low costs do not justify the effort required to set up and execute the analytical approach; however, this does not necessarily exclude planning and coordination activities using the airport's own staff. In these cases, the cost can be represented as the costs associated with the staff hours dedicated to the project.

The main sources used for the initial identification of IROPS mitigation initiatives were the following:

- Individual airport tarmac delay contingency plans.
- Best industry practices for managing IROPS.
- The research team's experience and subject matter expertise.

The airport tarmac delay contingency plans are required by the U.S.DOT in accordance with the FAA Modernization and Reform Act of 2012 (U.S.DOT 2012b). A sample of 50 airport contingency plans was collected and reviewed by the research team. These airports are identified in Table 5.

The resulting list of identified IROPS mitigation initiatives is shown in Table 6 in alphabetical order. Notice that some of the initiatives listed mitigate IROPS through an indirect mechanism. For example, airports that use their own staff to perform ground-handling services under contractual arrangements with airline tenants have potentially greater flexibility in assigning staff resources in response to IROPS events.

**Table 5. Airports in extended tarmac delay contingency plan sample.**

Antonio B. Won Pat International Airport (Guam)	Lehigh Valley International Airport (Allentown, PA)
Billings Logan International Airport (Billings, MT)	Lexington Blue Grass Airport (Lexington, KY)
Bob Hope Airport (Burbank, CA)	Long Island MacArthur Airport (Ronkonkoma, Town of Islip, NY)
Boise Airport (Boise, ID)	Mammoth Yosemite Airport (Mammoth Lakes, CA)
Casper/Natrona County International Airport (Casper, WY)	Minneapolis-St. Paul International Airport (Minneapolis and St. Paul, MN)
Charlotte Douglas International Airport (Charlotte, NC)	Missoula International Airport (Missoula, MT)
Chicago Midway International Airport (Chicago, IL)	Newark Liberty International Airport (Newark, NJ)
Corpus Christi International Airport (Corpus Christi, TX)	Norman Y. Mineta San Jose International Airport (San Jose, CA)
Colorado Springs Airport (Colorado Springs, CO)	Northwest Florida Regional Airport (Fort Walton Beach, FL)
Cincinnati/Northern Kentucky International Airport (Hebron, KY)	Oakland International Airport (Oakland, CA)
Daytona Beach International Airport (Daytona Beach, FL)	Outagamie County Regional Airport (Appleton, WI)
Dane County Regional Airport (Madison, WI)	Pensacola International Airport (Pensacola, FL)
Dallas/Fort Worth International Airport (DFW Airport, TX)	Pittsburgh International Airport (Pittsburgh, PA)
Denver International Airport (Denver, CO)	Portland International Airport (Portland, OR)
Dubuque Regional Airport (Dubuque, IA)	Raleigh-Durham International Airport (Morrisville, NC)
Fort Lauderdale-Hollywood International Airport (Fort Lauderdale, FL)	Richmond International Airport (Richmond, VA)
Fresno Yosemite International Airport (Fresno, CA)	Salt Lake City International Airport (Salt Lake City, UT)
General Mitchell International Airport (Milwaukee, WI)	San Diego International Airport (San Diego, CA)
George Bush Intercontinental Airport (Houston, TX)	Santa Fe Municipal Airport (Santa Fe, NM)
T. F. Green Airport (Warwick, RI)	Sarasota Bradenton International Airport (Sarasota, FL)
Houghton County Memorial Airport (Calumet Township, MI)	Seattle-Tacoma International Airport (SeaTac, WA)
Huntsville International Airport (Huntsville, AL)	Spokane International Airport (Spokane, WA)
Jacksonville International Airport (Jacksonville, FL)	Washington Dulles International Airport (Sterling, VA)
John F. Kennedy International Airport (New York, NY)	Will Rogers World Airport (Oklahoma City, OK)
	William P. Hobby Airport (Houston, TX)
	Yellowstone Regional Airport (Cody, WY)

## 2.4 The IROPS Business Case Analysis

The existing body of literature on IROPS planning combined with airports' individual contingency plans provides the basic tools required to respond to IROPS. They do not, however, provide the tools for optimizing the allocation of limited funds across a set of IROPS mitigation initiatives. The goal of developing an IROPS business case methodology is to fill that need. Specifically, the goal consists of implementing and testing an approach to assess investments intended to minimize the impact of IROPS events on passengers and aircraft operators, as well as on the airport's own infrastructure, staff, and neighboring communities.

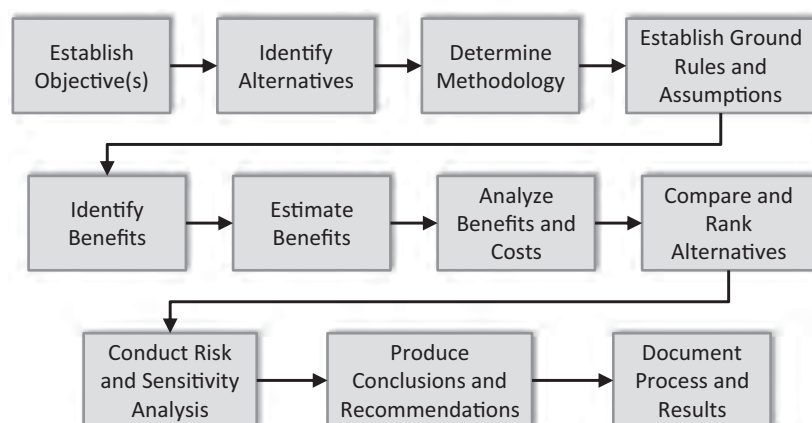
To provide useful information, business planning for IROPS must be able to handle multiple variables and high levels of uncertainty. The process must also be straightforward to use for

**Table 6. IROPS mitigation initiatives.**

<b>Description</b>	<b>Type</b>
Acquire additional remote aircraft parking stands	Capital
Acquire alert system for aircraft diversions headed to airport	Capital
Acquire buses	Capital
Acquire communication software system	Capital
Acquire ground power units	Capital
Acquire passenger lifts	Capital
Acquire portable stairs	Capital
Acquire supplies for stranded passengers (e.g., cots, blankets, pillows, diapers, wipes, formula for babies, sanitary items, Meals Ready to Eat [MREs], etc.)	Capital
Acquire surface management software	Capital
Add additional terminal space that can be configured as sterile space for temporary customs/immigration processing	Capital
Construct additional gates	Capital
Contract with airlines to use airport personnel to provide ground-handling services	O&M
Develop IROPS/coordination plan	O&M
Establish communications center	Capital
Hire additional staff	O&M
Modify existing airline use agreements to allow airports to use exclusive use gates during IROPS events	O&M
Practice/simulate IROPS scenarios	O&M
Provide emergency electrical generators	Capital
Review plans to get airport staff from off-airport to work	O&M
Review plans to house and feed airport staff that are stranded at airport	O&M
Set aside contingency funds to pay for meals	O&M
Strengthen network with airports that are diversion generators	O&M
Train staff to assist with deplaning of passengers	O&M
Upgrade generator capability for terminal facilities	Capital

airport management staff without formal training in business case analysis. Finally, it must maintain a correct level of analysis to avoid the proverbial “paralysis by analysis.” A well-structured business-planning process will produce clear and insightful results that project sponsors can rely on to select the best value options to meet their strategic objectives. The business-planning approach should accomplish the following objectives:

- Clearly capture and present alternatives, benefits, costs, and risks.
- Be credible, defensible, and useful for effective decision-making with the goal of maximizing the use of scarce resources.
- Comply with FAA and other federal agency requirements.
- Support strategic goals and higher-level budget processes.
- Reduce the time required from concept to implementation.
- Minimize the cost of delivering safe and secure airport services to the aviation community and the public.
- Manage the risks and uncertainty inherent in investment decisions.
- Provide decision makers with a clear, standardized, and understandable rationale for funding requests for IROPS mitigation.
- Reduce the risk of inefficient investment decisions resulting from subjective evaluations, political pressure, and other types of pressure.



**Figure 1. Traditional business case analysis.**

- Provide documentation of the economic evaluation of investment options, using quantifiable metrics.
- Support funding requests that help achieve strategic goals.

A well-designed business-planning approach should produce end products that are concise, useful, credible, and insightful, so that airport sponsors have the right information to make decisions. This analysis supports the role of business planning throughout a program's lifecycle to guide decisions on how to best use scarce resources to meet the airport's objectives. Use of the approach should result in effective investment decisions that are in compliance with FAA regulations and applicable advisory circulars.

Figure 1 illustrates the systematic process traditionally used to develop business-planning products for a broad range of aviation infrastructure and airfield investments. The process begins with identifying objectives. This step helps identify alternative reasonable, feasible, and effective solutions that meet the objectives. The process then identifies, quantifies, and estimates costs and benefits; ranks and evaluates initiatives through benefit-cost ratios and other investment metrics; and performs sensitivity and risk analysis.

## 2.5 Limitations of Traditional Business Case Analysis

Business case analysis for air transportation investments is an established science. The traditional business-planning approach is the benefit-cost analysis. For several reasons, however, the benefit-cost analysis may not be the most effective method for business planning for IROPS mitigation initiatives. These reasons include the following:

- Conducting a benefit-cost analysis for an IROPS mitigation initiative is labor intensive. It would require a quantitative assessment of the frequency of the IROPS event(s) under consideration, as well as a study of the impact of the event with and without the mitigation in place. Completing such assessments may be difficult because IROPS events are associated with an unusually high level of uncertainty.
- Not all benefits of investments intended to mitigate IROPS events can be expressed in standard fashion (i.e., monetary amounts) using current FAA guidance on investment analysis for airports. Although it is common for benefit-cost analyses to include both quantitative and qualitative benefits, the former can be entered into the computation of a benefit-cost ratio, which is easy to interpret by decision makers.

- Existing FAA guidance on benefit-cost analyses for airport projects focuses on measuring the economic benefits of capacity enhancement projects. Consequently, much of the guidance may not apply to the evaluation of IROPS-related projects.
- Airport activity metrics used for benefit-cost analyses focus on accepted airport planning practices that draw on averages, which may not capture the volatility in activity during IROPS events.

For these reasons, this guidebook employs a decision analysis approach based on the AHP methodology. This approach can be used to rapidly evaluate initiatives across a wide range of criteria. Described in detail in Chapter 3, this framework supports decision-making even when not all aspects can be monetized (i.e., evaluated as dollar values). In lieu of monetary benefits, measures of effectiveness are used which can be quantified by incorporating expert evaluations by the airport management team to determine relative effectiveness. The framework also takes into account that, for airport operators, dealing with unexpected events is to some extent “just another day” at the airport. The approach is designed to capitalize on the experience of the airport management staff and incorporate decision-maker preferences. It combines these subjective evaluations with objective metrics such as lifecycle cost, to prioritize choices among a set of alternatives.

Notice that no formal training or education in the AHP technique is required to use the business-planning approach or the Microsoft Excel-based decision support tool presented in this guidebook. The process is described in detail, but this information is intended primarily for readers who are interested in obtaining a deeper understanding of the business-planning approach and the results generated by IRIS. The material presented on the methodology should be viewed as optional and is not required to make use of accompanying software. IRIS was developed under the assumption that it would be adopted at a broad range of airports.

Even though traditional business-planning methodologies cannot always be applied effectively to IROPS business-planning problems, the steps illustrated in Figure 1 still have applicability to this project. Metrics and methods that are part of current industry practices and part of the FAA’s guidance on investment analysis can be used when relevant. For example, an airport can base its evaluation of effectiveness on monetized savings in aircraft operator costs and passenger value of time. Such estimates can be developed using FAA guidance on the economic value of aircraft operator and passenger benefits (FAA 2013b). Conversely, multi-day disruptions to the itineraries of passengers, crew, and aircraft cannot be monetized using existing standards and, therefore, require an alternative valuation, such as the one used in the methodology presented here.

To provide additional background information on business case analysis, Appendix A includes a primer on the topic. The primer focuses on the benefit-cost analysis. It explains the framework used to formally map out benefits and costs and discusses the key principles of both benefit and cost estimating. This primer should be of value to the reader who wants a deeper understanding of traditional business case analysis. It helps highlight the similarities and differences between the benefit-cost analysis and the decision-making approach presented in this guidebook. It also contains useful “how to” information about the elements of traditional business case analysis that are retained in the approach presented in this guidebook, notably cost estimating. *ACRP Synthesis 13: Effective Practices for Preparing Airport Improvement Program Benefit-Cost Analysis* (Landau and Weisbrod 2009) provides additional reference material for the reader wishing to explore the benefit-cost analysis in more depth.

## 2.6 Cost Estimating

Cost estimating is one aspect of traditional business case analysis methodologies that carries over into the business-planning approach described in this guidebook. The resulting cost estimates are used differently here than in a benefit-cost analysis, but lifecycle cost is one of the required inputs for the analysis.

When the mitigation strategy involves the procurement of commercial-off-the-shelf (COTS) products, a cost estimate is relatively easy to obtain. The cost can be determined simply, using the purchase price or a quote provided by one or more potential vendors. For anything other than a straightforward COTS procurement, however, cost estimating becomes much more complex. This happens in part because airport equipment acquisition and construction usually require significant planning, design, and engineering activities. Frequently, site surveys, soil testing, and permitting are required. Construction is usually preceded by site preparation activities, which can be extensive. Implementation can also add activation, documentation, and training costs. Prime contractors and airport personnel are involved. Similarly, O&M activities can include a range of maintenance, modifications, and tech refresh activities. Each cost element can be complex enough to require substantial analysis.

In many cases, cost data will be available as an outcome of the airport's regular capital planning process. Estimates of construction and acquisition costs developed for the Airport Capital Improvement Plan (ACIP) are typically provided by the airport's engineer (in-house or through a consultant appointment). Such cost estimates are fully usable for IROPS business planning. The estimated costs may have to be converted into lifecycle costs, which typically requires adding O&M expenses and any upgrades planned during the lifecycle.

In the absence of existing cost estimates, the airport may need to develop cost estimates. The primer on business case analysis presented in Appendix A contains an introduction to cost estimating. More in-depth information, including best practices, can be found in existing reference material, notably the U.S. Government Accountability Office's *Cost Estimating and Assessment Guide* (U.S. GAO 2009). Airport-specific guidance on cost estimating is also available through the FAA's guidance on benefit-cost analyses for airport projects (FAA 1999). Additional guidance on airport project cost estimating will be available from ACRP Project 1-19, "Airport Capital Improvements: Developing a Cost-Estimating Model and Database," which is expected to be completed in 2014.

## 2.7 Overview of the Business Case Methodology for IROPS Business Planning

As discussed in Section 2.5, traditional business case analysis that estimates the costs of an initiative and compares them to monetized benefits is not always well-suited to IROPS challenges. Instead, this guidebook uses an integrated approach that merges decision analysis with traditional benefit-cost methodologies. This approach establishes a proxy for monetized benefits by estimating a benefit function of likelihood and impact of the associated IROPS event as well as the effectiveness of the mitigation initiative. AHP is used to evaluate and quantify effectiveness, and the resulting benefit calculation is then compared against cost data.

The process used in this guidebook provides a comprehensive evaluation of the likelihood, impact, effectiveness, and costs of proposed IROPS mitigation initiatives. Moreover, the selected approach is suitable for incorporation in the IRIS decision support tool distributed with this guidebook for use in Microsoft Excel. The IRIS decision support tool cannot capture all issues that affect an investment decision and does not attempt to replace the judgment of the airport management team regarding what strategy to pursue; however, the tool provides an analysis of potential benefits to airport stakeholders, including a broad spectrum of the financial, tactical, and strategic considerations related to the possible mitigation initiatives. The tool also provides documentation that can support the recommended investment decision.

IRIS allows the airport management team to specify a set of IROPS events and potential impacts to be included in the business-planning process. IRIS provides decision support for evaluating the initiatives under consideration to mitigate the negative impacts of those IROPS

events. The user identifies the potential alternatives under consideration by creating an *investment portfolio* of mitigation initiatives. The initiatives should match the IROPS events and the impacts they are designed to address.

The user then provides additional input to allow for the evaluation of the likelihood, impact, effectiveness, and costs associated with the investment portfolio. IRIS processes this input to generate an overall score for each IROPS mitigation initiative in the portfolio. Those scores are used to rank order the portfolio and can be used as guidance on which options would be most effective to fund.

Effectiveness is measured using AHP, an established, structured decision analysis technique. AHP merges the stakeholders' objectives with their evaluation of the problem to provide insight on complex planning problems. The process involves breaking the problem into manageable parts and arranging them in a logical hierarchy. By making simple comparisons between the sub-elements of the hierarchy, potential outcomes can be prioritized. The utility of this technique lies in its ability to synthesize human judgment with quantitative metrics in an organized way to prioritize choices across multi-dimensional, complex problems.

Consequently, the benefit of IRIS is that it takes a large number of decision parameters into account. The tool capitalizes on the experience, expertise, and skills of the airport management team, and synthesizes the available information into a defensible ranking of IROPS mitigation options. These options are supported with numerical scores that can then be used in the capital planning process. The scores also are useful as support material when presenting funding recommendations to decision makers.

A demonstration project was implemented to test IRIS in the field across a targeted but representative group of airports. A formal assessment of the demonstration project was used to refine the model and prepare the documentation of the research results. The final version of IRIS includes a number of improvements that incorporate the feedback provided by these airport users. Details of the final business-planning approach are presented in Chapter 3. Chapter 4 discusses implementation of the business-planning approach (i.e., the conversion of the selected methodology into the IRIS decision support tool).

## CHAPTER 3

# IROPS Business Planning Using Decision Analysis

As described in Chapter 2, in a benefit-cost analysis the lifecycle costs of a mitigation initiative would normally be compared against a monetized evaluation of benefits. The basic objective is to provide decision makers with the net financial value of a project. This process can be labor intensive and time consuming, however, especially if many alternatives need to be considered or if the level of uncertainty is unusually high. Also, in many cases, the finances of a project are not the only considerations. The definition of benefits can vary, not all aspects may be possible to monetize, or levels of uncertainty may be higher than normal, and stakeholder preferences may need to be included. In these cases, decision analysis (or decision theory) can be used as an alternative to other techniques.

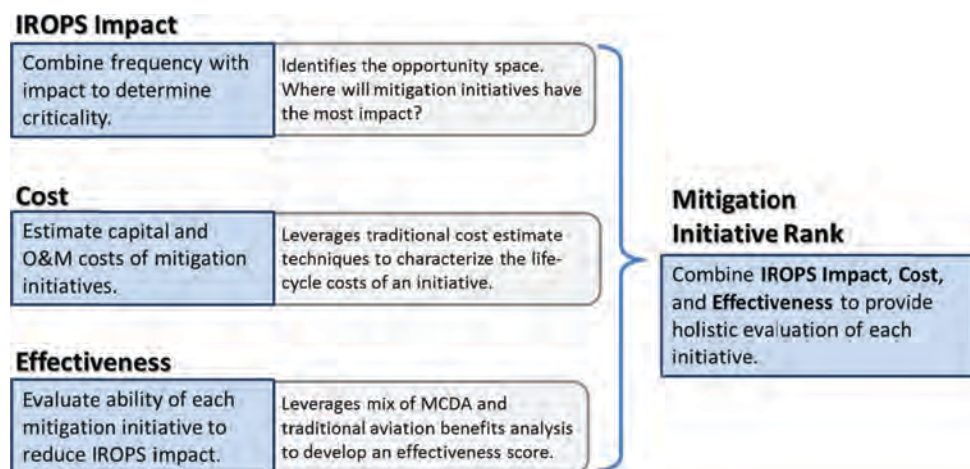
Decision analysis identifies the factors that enter into a decision, and quantifies their impacts and uncertainties to arrive at an optimal decision. The method can be implemented using different mathematical techniques to identify the key factors of a decision and then recommend a course of action. First, a framework is defined that models the decision-making process, including the key factors and alternatives being considered. The selected mathematical method is then used to quantify the effectiveness of each potential decision. The results can be used to rank the initiatives and present recommendations to the decision maker.

## 3.1 The Analytic Hierarchy Process

AHP helps decision makers structure a decision problem into layers of sub-problems. The resulting layers form a hierarchy, which gives the method its name. AHP is a specific application of multi-criteria decision analysis (MCDA), a discipline within operations research (Saaty 1980). The goal of MCDA is to support decision-making under multiple and opposing criteria—in this case, cost of a mitigation initiative, likelihood and severity of an IROPS event, and the effectiveness of the proposed mitigation.

AHP augments traditional benefit-cost analysis to provide a comprehensive evaluation of each potential mitigation initiative. Under AHP, decisions are evaluated using a mathematical formulation of effectiveness that takes into account both quantitative analysis and human judgment. Incorporating both perspectives has the advantage of allowing the analyst to quickly examine decisions that would otherwise be difficult to measure. The resulting evaluation of effectiveness replaces the monetary evaluation of benefits that would be used in a traditional benefit-cost analysis. Figure 2 diagrams the high-level approach for determining the impact of IROPS events, estimating the costs, and evaluating the impact of mitigation initiatives.

The *impact* of an IROPS event refers to the potential severity of the consequences. For example, at an airport that is used to winter weather conditions, an icing event may be disruptive,



**Figure 2.** *Decision analysis approach for IROPS business planning.*

but not severely so. At an airport that normally does not experience snow or ice, however, an icing event has the potential to essentially shut down the airport for several hours, resulting in extended tarmac delays. If all other factors are equal, a mitigation initiative that mitigates IROPS events with more severe impacts should be ranked higher than alternatives that address less severe ones.

Impact must also take into account the likelihood of occurrence: An IROPS event with a severe impact that is unlikely to occur should carry less weight in the decision-making process than one with a lower impact but that is much more likely to happen.

In this decision analysis framework, benefits cannot be compared directly against costs because the benefits are not monetized. Instead, a notional form of benefit is used, which combines impact and effectiveness:

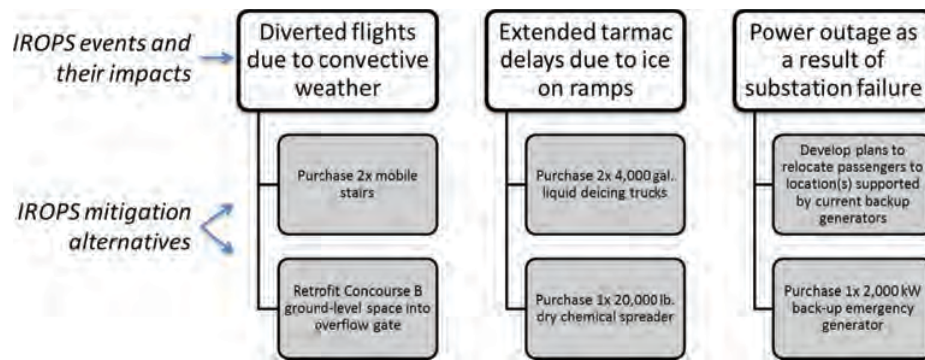
$$\text{Benefit} = \text{Impact} \otimes \text{Effectiveness},$$

where the operator  $\otimes$  represents a positive interaction between impact and effectiveness. In general, the greater the effectiveness of the mitigation initiative, the greater is the resulting benefit. Similarly, the greater the disruptive impact of an IROPS event—and the more likely the event is to occur—the greater is the benefit of investing in a mitigation initiative. Using the decision analysis approach allows both impact and effectiveness to be quantified. This, in turn, allows for the benefit of an IROPS mitigation initiative to be quantified. The benefit values can then be compared against relative cost to determine which alternatives provide the best investment. (Relative cost is used since the comparisons are not made in monetary terms.)

The remaining sections of this chapter describe how these concepts are combined to design a business-planning approach for IROPS. The description uses a notional example that illustrates application of the decision analysis approach. Chapter 4 describes the particulars of how the approach is implemented in the Microsoft Excel-based decision support tool IRIS.

### 3.2 IROPS Investment Portfolio

The basic element being evaluated under this approach is the IROPS investment portfolio. Here, the term *portfolio* refers to a list of alternative mitigation initiatives under consideration. The airport management team determines which IROPS events and impacts they would like to



**Figure 3.** Sample investment portfolio for IROPS mitigation initiatives.

address and then develops potential mitigation initiatives to address their concerns. The completely user-defined portfolio defines the investment options under consideration by matching potential mitigation initiatives to the IROPS events and impacts they are designed to address. Figure 3 provides an example of an IROPS investment portfolio.

### 3.3 IROPS Impact

Contingency planning includes the unique challenge of addressing a variety of events that often occur very infrequently and have a wide range of impacts on operations. The objective of this step in the process is to determine both the frequency and impact of each IROPS event under consideration. This step defines the *opportunity space* for the mitigation initiatives. For example, using scarce resources to develop an optimal mitigation approach for an IROPS event that is extremely likely to occur but has a minimal disruptive impact may not be in the best interest of the airport. For this reason, the business-planning approach requires both an estimate of the likelihood (or probability) of an IROPS event occurring and an evaluation of its impact on airport operations.

The overall severity of an IROPS event can be thought of as a combination of two things: (1) the likelihood of the event happening and (2) the impact on the airport and its customers if the event does occur. This combination can be expressed through a conceptual impact rating, which is written as follows:

$$\text{Impact} = \text{Likelihood of IROPS Event} \otimes \text{Severity of IROPS Event}.$$

Such evaluations of likelihood versus severity are commonly used in the risk management field. The approach presented in this guidebook for IROPS business planning uses the risk assessment matrix from the FAA draft Advisory Circular *Safety Management System for Airports* (FAA 2012b, 30) and is shown in Figure 4. This matrix is substantially similar to the risk assessment matrix used in *ACRP Report 74: Application of Enterprise Risk Management at Airports* (Marsh Risk Consulting 2012, 31).

For each event in the investment portfolio, the user provides subjective evaluations for both the likelihood and the severity of the event. Each rating is quantified using a five-step scale as shown in Figure 4. The intersection of the likelihood rating and severity rating determines the overall level of risk using a three-step scale (i.e., low, medium, and high). This risk level is then assigned a numerical value for the quantitative assessment of impact of each IROPS event associated with the mitigation initiatives in the IROPS investment portfolio.

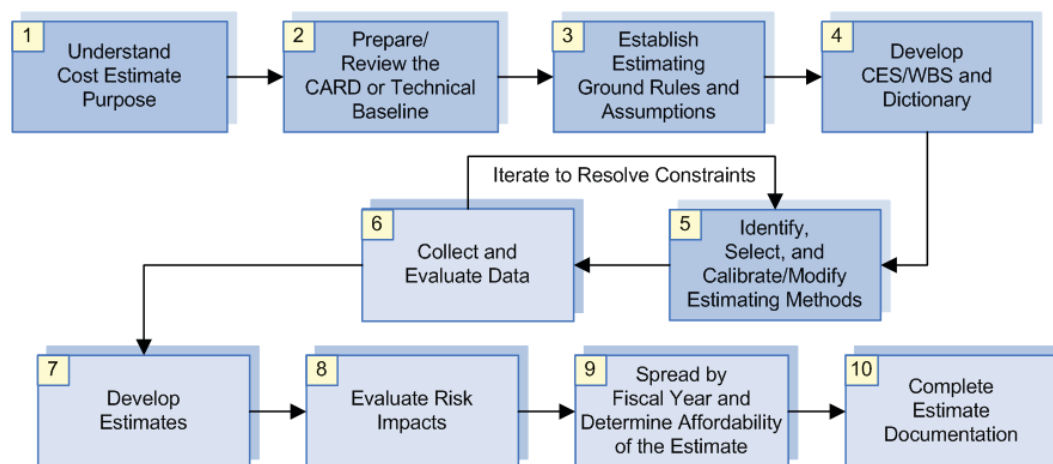
Severity \ Likelihood	Minimal 5	Minor 4	Major 3	Hazardous 2	Catastrophic 1
Frequent A	Low	Medium	High	High	High
Probable B	Low	Medium	High	High	High
Remote C	Low	Low	Medium	High	High
Extremely Remote D	Low	Low	Low	Medium	High
Extremely Improbable E	Low	Low	Low	Low	High Medium

**Figure 4. Risk matrix from FAA Safety Management System for Airports.**

### 3.4 Costs

As described in Chapter 2, the cost input required for the IROPS mitigation business-planning approach is the same as that used for traditional benefit-cost analyses. The total lifecycle cost is needed (in IRIS it is entered as an initial acquisition cost and a recurring O&M cost). Lifecycle cost estimates include the total costs to acquire, implement, operate, maintain, tech refresh, and dispose of the proposed initiative. The lifecycle must be selected commensurate with the measures of effectiveness. Also, to allow for an economic analysis to be performed, the same lifecycle must be used for all alternatives in the IROPS investment portfolio.

It is expected that airports will obtain costs from vendor quotes, existing engineering estimates, or through the separate development of a cost estimate. Figure 5 presents a typical cost-estimating process. General best practices for developing cost estimates are described in the business case analysis primer in Appendix A. This guidebook is not, however, intended as an exhaustive reference on cost estimating. Users of IRIS may need to refer to other sources for some cost data, depending on the scope and complexity of the proposed mitigation initiative.



CARD = cost analysis requirements description; CES = cost-estimating structure; WBS = work breakdown structure.

**Figure 5. Generalized cost-estimating process.**

**Table 7. Simplified WBS.**

<b>Acquisition Costs</b>	<b>Year 1</b>	<b>Year 2</b>	<b>Year 3</b>	<b>...</b>	<b>Last Year</b>	<b>Total Cost</b>
Program office management						
Research and development						
Site surveys						
Engineer technical solution						
Purchase COTS materials, equipment, software						
Develop/customize software						
Site preparation						
Construction of facilities						
Utilities and telecommunications						
Installation						
Testing and activation						
Documentation						
Training						
<b>Operations and Maintenance (O&amp;M) Costs</b>	<b>Year 1</b>	<b>Year 2</b>	<b>Year 3</b>	<b>...</b>	<b>Last Year</b>	<b>Total Cost</b>
Program office management						
System operations						
Maintenance labor						
Maintenance parts						
Utilities and telecommunications						
Fuel						
Periodic tech refresh						
Modifications						
Training						
<b>Total Costs</b>						

For complex mitigation initiatives (e.g., those involving construction), the airport would normally be expected to have a cost estimate developed as part of its long-term capital planning process. Cost estimates from the ACIP can be used as inputs to the decision support tool, although they may need to be supplemented with O&M and upgrade costs.

For these reasons, the IROPS business-planning approach uses cost estimates at a highly distilled level. The user provides initial costs and recurring costs, with single fields for total acquisition costs and O&M costs. For simpler mitigation strategies, these totals may be readily derived using simple arithmetic in a spreadsheet. To derive the cost inputs for more complex mitigation strategies, the standard cost-estimating practice is to break down total system costs into a standardized work breakdown structure (WBS). The WBS facilitates the comparison of alternatives, as differences in the individual cost elements are readily visible. To simplify the exercise for airport operators, use of an abridged WBS such as the one presented in Table 7 is suggested.

### 3.5 Evaluating the Effectiveness of IROPS Mitigation Initiatives

The rarity and potential severity of IROPS events prevents the use of traditional data-driven benefits or similar measurements of effectiveness, especially when designing a business-planning approach for use by a broad range of airports. The approach presented in this guidebook leverages AHP, an established decision analysis technique. It merges the stakeholder's

objectives with their evaluation of the problem to analyze complex business-planning problems in a structured way.

As applied here, the effectiveness of IROPS mitigation initiatives is assessed in three distinct steps:

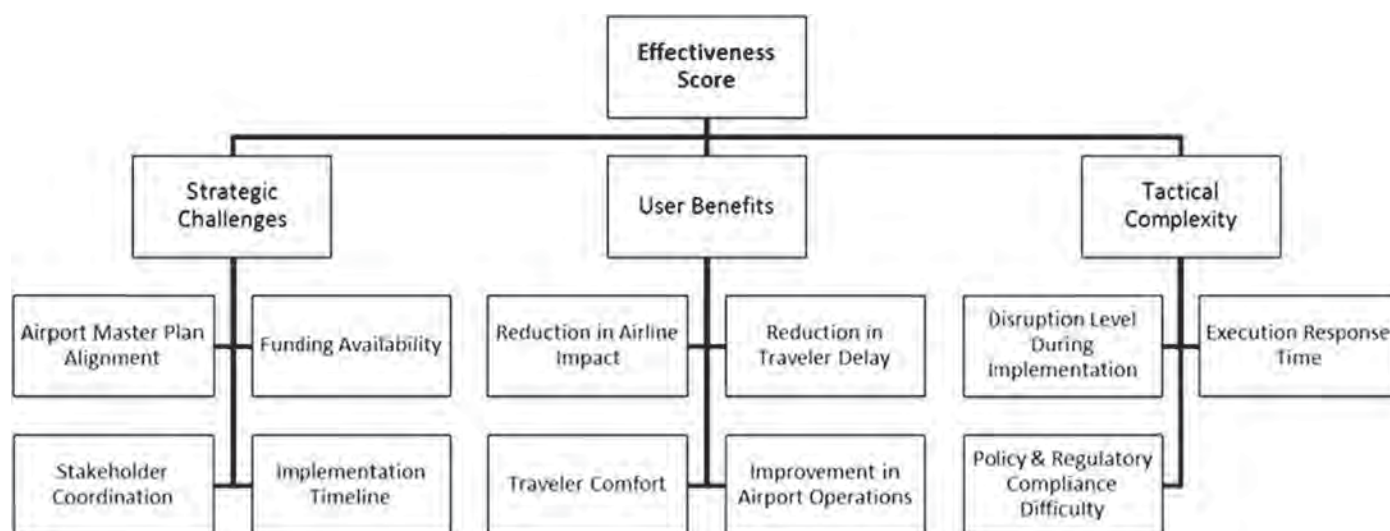
1. Review and understand the evaluation criteria.
2. Weight the criteria to incorporate stakeholder preferences.
3. Evaluate each mitigation initiative against the criteria.

A common understanding of the predetermined evaluation criteria is essential among evaluators and serves as the foundation of the effectiveness rating process. At the core of an AHP-based approach is the hierarchy that breaks down the decision analysis process into distinct manageable parts. The hierarchy adopted in this guidebook evaluates the effectiveness of mitigation initiatives across a set of criteria categorized into three major focus areas: strategic challenges, user benefits, and tactical complexity. Figure 6 illustrates the hierarchy. Definitions for each criterion in the hierarchy are listed in Table 8.

One of the most valuable aspects of AHP is allowing each evaluation to be driven by the preferences of the airport management team that is executing the approach. This flexibility enables AHP to be used for evaluation by a wide range of airports that have varying concerns, while still providing a structured and predetermined approach. After reviewing the criteria, the airport management team must determine which evaluation criteria are most important to its concerns. This ranking of the criteria establishes the most influential factors in analysis.

The IROPS business-planning approach uses pairwise comparison to measure and quantify stakeholder preferences. This method assists in deriving clear preferences, as other approaches tend to include too little differentiation. Pairwise comparisons also ease understanding of the evaluation process by providing simple one-on-one comparisons. A sample pairwise comparison is shown in Figure 7.

A numerical scale is used to value the relative importance of each pair of choices. The rating scale is based on the perception and experience of the respondent (Table 9). It is important to remember that the pairwise comparisons are based on human judgment and that stakeholder preferences can change over time. Consequently, different evaluations of criteria can yield different results.



**Figure 6.** *Hierarchy of effectiveness criteria.*

**Table 8. Definitions of IROPS mitigation effectiveness criteria.**

Evaluation Criteria	Description
<b>Strategic Challenges</b>	
Airport Master Plan alignment	How well does the mitigation initiative align with the current Airport Master Plan? Was it already considered in the capital plan? Is it a completely new concept?
Funding availability	How accessible will funding be for this initiative? Does it qualify for a federal grant, PFC funding, PFC-backed bonds or other public funding? Airport-generated funds? Does this create a significant ongoing operational expense to the airport?
Stakeholder coordination	How many stakeholders must be involved for this initiative? What level of coordination is required across different interested parties? What are the potential related complications? What is the impact on rates and charges? Airline use agreements?
Implementation timeline	How long will the initiative take to procure/implement?
<b>User Benefits</b>	
Reduction in airline impact	How will this mitigation initiative reduce disruption to airlines in terms of time? Consider flights delayed, missed connections, crew scheduling, and extended tarmac delays.
Reduction in traveler delay	How will this mitigation initiative reduce delay experienced by travelers? Consider the value of the travelers' time, missed connections, and baggage lost.
Traveler comfort	What level of comfort can be provided to travelers during the IROPS event? Consider access to food, water, bathrooms, cots, telephone, the Internet, airport/airline information, onsite overnight accommodations. Consider impacts on travelers with special needs and persons with mobility impairments.
Improvement in airport operations	How does the mitigation strategy impact the work conditions for airport staff during IROPS events?
<b>Tactical Complexity</b>	
Disruption level during implementation	What level of disruption will this mitigation initiative cause to normal airport operations when it is in effect? Note: This criterion should <b>not</b> include disruption associated with the acquisition/construction of the initiative (e.g., temporary disruptions because of construction activity).
Execution response time	How quickly can this mitigation initiative be executed to address the IROPS event?
Policy and regulatory compliance difficulty	How difficult will it be to maintain policy and regulatory compliance during the execution of the mitigation initiative? Consider security, Federal Aviation Regulations Part 139, safety, and so forth.

**Pairwise Comparisons**

Which is more important to your airport when considering investment in mitigation initiatives?

a) Airport Master Plan Alignment

b) Stakeholder Coordination

**How much more important?**

Equally Important	1
Moderately More Important	3
Strongly More Important	5
Very Strongly More Important	7
Extremely More Important	9

**Figure 7. Sample pairwise comparison.**

**Table 9. Rating scale for pairwise comparisons.**

Intensity of Importance	Definition	Explanation
1	Equal importance	Two elements contribute equally to the objective.
3	Moderate importance	Experience and judgment moderately favor one element over another.
5	Strong importance	Experience and judgment strongly favor one element over another.
7	Very strong importance	One element is favored very strongly over another; its dominance is demonstrated in practice.
9	Extreme importance	The evidence favoring one element over another is of the highest possible order of affirmation.

Note: Intensities of 2, 4, 6, and 8 can be used to express intermediate values. Intensities of 1.1, 1.2, 1.3, etc., can be used for elements that are very close in importance.

The AHP method requires that the pairwise valuations maintain internal logical consistency. For example, it is not possible that initiative **A** be more important than **B**, initiative **B** be more important than **C**, and initiative **C** be more important than **A**. For this reason, the IRIS decision support tool includes a validation process of the pairwise comparisons. The validation test computes a consistency ratio that measures the extent to which the pairwise comparisons are logically consistent. The resulting ratio cannot exceed a prespecified error threshold. If the error threshold is exceeded, the user will be prompted to repeat the pairwise evaluation or to use suggested values provided by the decision support tool. This feature of the tool prevents the user from executing the decision analysis with inconsistent choices in place.

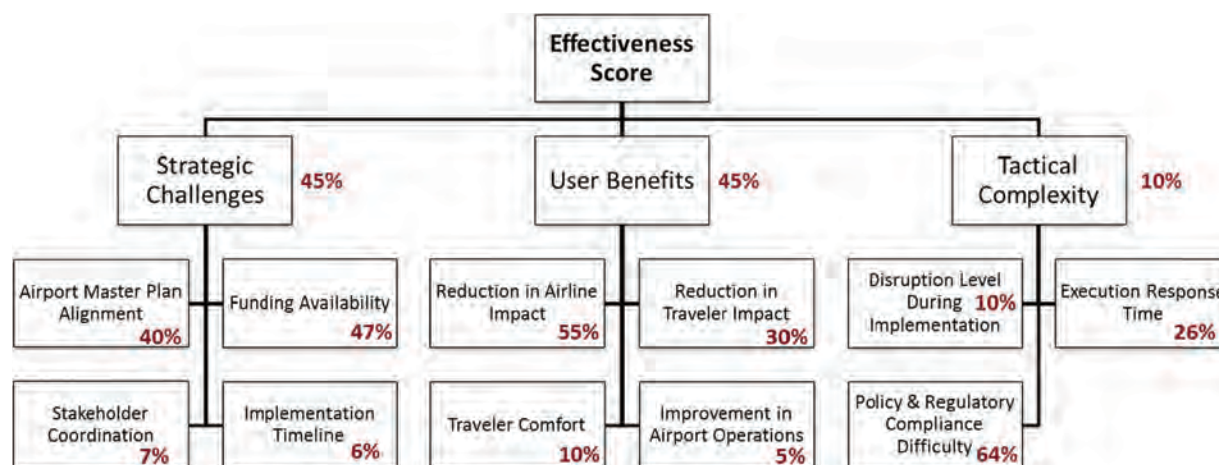
After each pairwise comparison is evaluated for relative importance, the responses are automatically encoded as shown in Table 10 and then converted into matrix form. The resulting scores are used to estimate the airport's stakeholder priorities by using them as weighting factors in the evaluation of the effectiveness of each IROPS mitigation initiative. An example of the processed results is shown in Figure 8.

The final step in assessing the effectiveness of mitigation initiatives is to evaluate each initiative within the IROPS investment portfolio against the criteria applied to the associated IROPS event(s) and impact(s). Initiatives are scored through a subjective evaluation of how effective each proposed initiative is at mitigating the impact of the IROPS event. A Likert scale modified for this purpose is used to obtain a quantitative assessment of effectiveness. For example, for the criterion "Airport Master Plan Alignment," the IRIS decision support tool poses the following question to the user:

How well does the mitigation initiative align with the current Airport Master Plan?

**Table 10. Sample analysis of pairwise comparisons.**

Category: Strategic Challenges			
Criterion	Score	Criterion	Score
Airport Master Plan alignment	1	Funding availability	1
	1	Stakeholder coordination	5
	1	Implementation timeline	7
Funding availability	1	Stakeholder coordination	7
	1	Implementation timeline	9
Stakeholder coordination	1	Implementation timeline	1



**Figure 8.** Sample computation of weightings of effectiveness criteria.

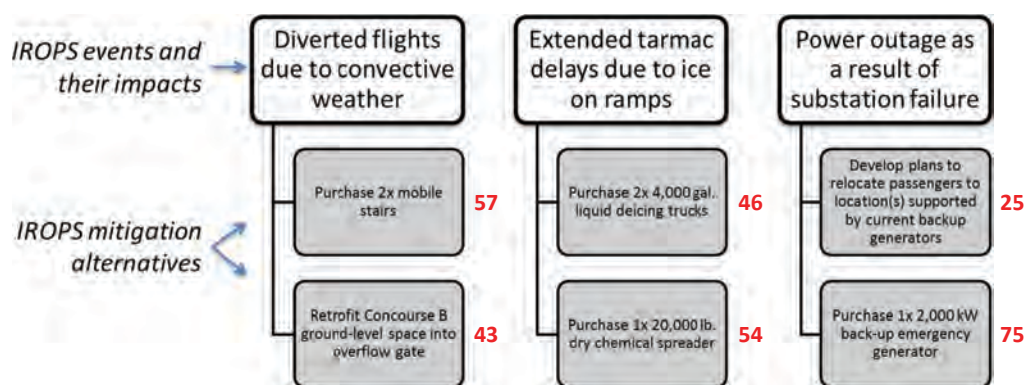
For each question, a five-step scale is provided to evaluate the effectiveness of the criterion in question. In this example, the user would be given the following response options:

- 5 = Very Well
- 4 = Well
- 3 = Adequately
- 2 = Poorly
- 1 = Very Poorly

Evaluations for each possible pairing of a proposed mitigation initiative with its associated IROPS event and impact are then computed by incorporating the effectiveness evaluations as weighted by stakeholder priorities. This process is repeated to iterate through each element in the investment portfolio. An overall effectiveness score for each initiative is calculated by applying the weights computed from the pairwise comparisons to the evaluation of each effectiveness criterion. The results for a sample IROPS investment portfolio are shown in Figure 9.

### 3.6 Rank Ordering the Investment Portfolio

The final step in the IROPS business-planning approach is the rank ordering of each initiative in the investment portfolio. This ranking compares the estimated benefit of each initiative against its lifecycle cost. As described previously, the evaluation of the overall benefit of each



**Figure 9.** Computed effectiveness scores (relative weights) for sample IROPS investment portfolio.

initiative is computed from its rated effectiveness and the impact score of the IROPS event. The impact score, in turn, is based on the estimated likelihood and severity of the event.

Given that the resulting benefit score does not represent a monetary value (as it would in a traditional benefit-cost analysis), it cannot be directly compared against a monetary cost. Consequently, a relative cost score is computed for each initiative in the investment portfolio. This cost score is the lifecycle cost of the initiative divided by the total lifecycle cost for all initiatives. The ranking of the IROPS investment portfolio is based on the ratio of the benefit score to this relative cost value. The higher this ratio, the more benefit is received for each dollar invested. Notice that in a traditional benefit-cost analysis, the value of the benefit-cost ratio can be used to determine whether or not the benefits are likely to exceed the cost of the investment. This occurs if the benefit-cost ratio is greater than 1. This sort of test is not possible for the ratio used to rank the IROPS investment portfolio. These ratios can be used to rank the relative merit of each IROPS mitigation initiative, but because benefits are not monetized in this method, the absolute value of the ratio conveys no meaning. The ratio should not be interpreted as a benefit-cost ratio.

## CHAPTER 4

# IROPS Investment Support (IRIS) Decision Support Tool

To implement the IROPS business-planning approach in a pragmatic way, this guidebook is accompanied by the IRIS decision support tool, an application developed in Microsoft Excel. IRIS uses AHP to prioritize and rank IROPS mitigation initiatives under consideration by an airport. IRIS provides a guided process that leads the user through each step in the business-planning approach and performs all necessary calculations, such as converting initial and recurring costs to a lifecycle cost and deriving the weightings used in AHP.

This chapter describes how the decision-making approach identified in Chapter 3 is implemented in IRIS. IRIS has been designed so that no formal training in business planning or decision analysis methodologies such as AHP is required to use the software tool. Nonetheless, most users will find it helpful to first read Chapter 1 through Chapter 3 in this report as well as the business case analysis primer in Appendix A.

Chapter 4 is organized to follow the sequence of tasks in IRIS. This workflow is defined in the sections that follow with an explanation of the purpose of each step. This chapter does not include detail on the mechanics of using IRIS, however. Information on how to install IRIS, save information, export results, and so on, is provided in the IRIS User Guide (Appendix B). A quick reference guide also is included on CRP-CD 144 for installation with the IRIS software, and it can be accessed from the main interface.

## 4.1 Before Getting Started with IRIS

To ensure a smooth experience with IRIS, some preparations are necessary before running the application. These preparations include the collection of information that constitutes inputs to the IROPS business-planning approach. IROPS business planning is interdisciplinary and involves management, policy, planning, finance, emergency response, security, and safety functions at the airport; therefore, the inputs should be vetted with relevant personnel and/or departments. Alternatively, IRIS can be run in a group setting to allow consensus discussion on the subjective inputs to the tool while it is being used.

Some of the inputs required by IRIS should be collected prior to starting. These are the inputs that define the portfolio under consideration. The portfolio is made up of the IROPS event(s), mitigation initiatives, initial costs, and recurring costs. The lifecycle duration to be used in the business plan and the cost escalation rate (if different from the default rate of 1.9%) should also be specified. A sample IROPS portfolio is shown in Appendix C.

Subjective evaluations of effectiveness are an important contributor to the final results, so it is important that IRIS users be familiar with the effectiveness criteria and the associated rating scale. Users should review the hierarchy of the criteria shown in Figure 6 in Chapter 3 and the

definitions of the criteria listed in Table 8. The scale used to rate the relative importance of the criteria is shown in Table 9. The definitions of the criteria and the rating scale can be displayed and printed from within IRIS. It may be useful to have a printed reference copy of this material while using IRIS, especially when using it for the first time.

## 4.2 IRIS Workflow

The main IRIS user interface serves both as a visual map of the workflow and as the interface for executing each step in the process (see Figure 10). These steps are as follows:

1. **Portfolio:** Defining the IROPS investment portfolio.
2. **Cost:** Specifying the initial and recurring costs, which are used to determine the lifecycle costs of the investment initiatives.
3. **Comparisons:** Conducting the pairwise comparisons between each criterion in the AHP hierarchy. The pairwise comparisons are used to compute the values for weighting the effectiveness scores.
4. **Effectiveness:** Evaluating the effectiveness of each investment initiative using the criteria in each level in the AHP hierarchy.
5. **Results:** Rank ordering the investments initiatives in the portfolio, with an accompanying table showing the impact, effectiveness, benefit, cost, and combined scores.

The implementation of the business-planning approach in IRIS uses the hierarchy and scoring definitions described in Chapter 3. For example, the AHP hierarchy is as shown in Figure 6, the criteria in each level of the hierarchy are as shown in Table 8, and the rating scale used for the pairwise comparisons used to calculate weightings is as shown in Table 9.

Each step is implemented using a wizard (a common user interface technique that guides the user through a complex task). The wizard consists of a short sequence of dialog boxes (i.e., windows), accompanied by brief instructions, that solicit the input required to execute each task. The required calculations occur in the background as the user completes the wizards.



Figure 10. Main IRIS user interface.

In short, IRIS can be said to consist of five wizards: The portfolio wizard, cost wizard, comparisons wizard, effectiveness wizard, and results wizard.

Each wizard contains a “Save” button that can be used to save any partial progress made within the wizard. Pressing this button saves any information that has already been entered to the Excel file, and it will remain even if the user exits the wizard. IRIS also supports the file-saving functions embedded in Microsoft Excel (under the “File” menu).

#### 4.2.1 Defining the IROPS Portfolio

The portfolio wizard helps the user execute the first step in the workflow when using IRIS. This wizard is used to define the IROPS portfolio. The portfolio has two dimensions: (1) the IROPS events under consideration, and (2) the initiatives under consideration to potentially mitigate each event. The information that must be entered for each IROPS event under consideration includes:

- **Description:** The name or identifying characteristics of the event (e.g., “International widebody aircraft diverted to airport”).
- **Likelihood:** The user’s best estimate of the probability that the event might occur at the airport. The options are:
  - Extremely improbable
  - Extremely remote
  - Remote
  - Probable
  - Frequent
- **Severity:** The user’s best estimate of the magnitude of the impact that the occurrence of the event would have on airport operations. The options are:
  - Minimal
  - Minor
  - Major
  - Severe
  - Catastrophic

In theory, the business approach described in this guidebook can be used to consider any number of IROPS events and mitigations; however, IRIS has built-in restrictions on the maximum allowable number. Specifically, IRIS supports up to five IROPS events in one portfolio. For each event, a maximum number of five mitigations can be specified. This means IRIS can consider investment portfolios of up to 25 mitigations. This limitation is the result of constraints on the user interface and computational limitations.

The business-planning problem under consideration should determine whether or not more than one IROPS event should be included when defining the portfolio. For example, if the airport is applying for a public safety grant that can be used for a broad range of IROPS-related mitigations, a portfolio with several events is likely to be the best choice. The events can be selected from among those that have the highest overall impact (i.e., combination of likelihood and severity). Conversely, if the airport wishes to address a known weakness in preparedness for a specific event (e.g., flooding), a single event should be used in the portfolio. Regardless of the number of events, up to five mitigations can be listed per event.

Because the portfolio wizard is the first step in the IRIS business-planning process, it is a convenient point in the workflow to collect information that supports the entire process. This includes the file name that will be used whenever work in progress is saved. It also includes the duration of the lifecycle, specified in years. The lifecycle is usually tied to the expected physical lifecycle of the initiative (e.g., 10 years for a vehicle), but this is not always the case. Because the rankings are based on comparing mitigations against each other, each with different recurring

costs, the same lifecycle duration must be used for all mitigations across all events. Doing this ensures that the rankings in the portfolio are not biased by having different numbers of years of recurring costs when computing the lifecycle cost used in the decision-making analysis.

The need for uniform lifecycle duration across the portfolio raises the challenge of how to handle initiatives with different service lives. For example, consider the comparison of an electronic communications system with a 10-year lifecycle against a pavement project with a 30-year lifecycle. Such disparities can be handled by including recurring costs that represent replacement or refurbishment costs for mitigation initiatives with shorter service lives. Such costs need to be converted into an average cost for each year in the lifecycle, but they can then be entered in the same way as any other recurring cost. This conversion is important to ensure that the results for all mitigation initiatives in the portfolio are comparable to each other.

#### 4.2.2 Defining Lifecycle Costs

Cost estimating is a discipline in its own right with its own set of software tools employed by cost analysts and engineers. To keep the process of defining lifecycle costs manageable while preserving the integrity of the cost-estimating process, IRIS uses a highly distilled structure for the input of costs. The lifecycle cost for each mitigation initiative is determined entirely through the following four inputs:

- **Initial Investment Cost:** This input is the estimated initial investment cost for each mitigation option, typically either a construction cost or an acquisition cost (e.g., in the case of equipment and vehicles). For planning projects, however, the initial investment cost may be the value of the labor hours spent by the airport's staff.
- **Recurring Cost:** This input is an estimate of the average cost expected to recur each year in the lifecycle. The estimate typically includes O&M costs, but may also include replacement or major refurbishment costs for investments with service lives shorter than the lifecycle duration. Replacement or refurbishment costs should be entered as the annual recurring cost, which can be estimated by spreading out the associated costs over each year in the lifecycle.
- **Lifecycle Duration:** This input is the number of years in the economic lifecycle of the investment analysis. Because the lifecycle duration is the same for all mitigation initiatives in the analysis, it is entered in the portfolio wizard instead of in the cost wizard.
- **Escalation Rate:** This input is a cost escalation rate expressed as an estimated annual percentage growth in cost. In the IRIS decision support tool, an escalation rate of 1.9% is used by default unless the rate is changed by the user. The default rate is based on the predicted year-to-year change in the chained price index provided by the Office of Management and Budget in its *Analytical Perspectives: Budget of the U.S. Government* (OMB 2013, 11). The most recent value can be found in the annual update of this document, if desired.

These four inputs are used to calculate lifecycle costs by combining the initial cost with the recurring cost for each year in the lifecycle duration, with the cost escalation rate applied. The calculation is represented by the formula given in Equation 1:

$$C = C_0 + \sum_{i=1}^n c(1+r)^{i-1} \quad (1)$$

where

$C$  = lifecycle cost,  
 $C_0$  = initial cost,  
 $c$  = recurring cost,  
 $n$  = lifecycle duration, and  
 $r$  = escalation rate.

The resulting lifecycle cost for each initiative in the investment portfolio appears in the summary report in the results wizard. In addition to the lifecycle cost, which is expressed in dollars, a cost score is shown in the summary report. The cost score is simply the lifecycle cost normalized by the sum of all lifecycle costs in the investment portfolio. This score is compared against the benefit score, to rank order the portfolio.

### 4.2.3 Determining Stakeholder Preferences Through Pairwise Comparisons

The fundamental concept of AHP is to decompose a decision-making problem into a hierarchy of sub-problems. In this case, the sub-problems are expressed as the evaluation of effectiveness criteria. The effectiveness criteria are structured into a hierarchy or decision-tree consisting of multiple levels, as shown in Figure 6. Within each level, the criteria are evaluated for importance and assigned a numerical score. Each level in the hierarchy represents a common area (e.g., “user benefits”) and is also evaluated. The resulting values are used as weightings for the evaluation of the criteria, and serve to indicate which decision areas are of highest priority to the user.

A strength of the business-planning approach presented in this guidebook is that it combines objective measures with subjective ones. For example, lifecycle cost is an objective measure computed from the initial cost, recurring cost, lifecycle duration, and cost escalation rate. Conversely, the benefit side, including the estimation of impact and effectiveness, often involves subjective estimates. Using subjective measures allows the method to capture stakeholder preferences and the expertise that is held by the airport management team. It also solves the problem of quantifying benefits that otherwise might be impossible to monetize. At the same time, combining objective measures with subjective ones makes the process subject to biases, as is the case in any process that uses subjective input.

To minimize biases and obtain a true evaluation of stakeholder preferences, the AHP method relies on pairwise evaluations. When conducting pairwise evaluations, two criteria are presented at a time, to be evaluated against each other. In IRIS, for example, the user may be asked to compare the criteria “Airport Master Plan Alignment” and “Stakeholder Coordination” and indicate which is of higher priority when investing in airport improvements to mitigate IROPS. (An example of a prompt in IRIS to perform a pairwise comparison appears in Figure 7).

By presenting the criteria in a pairwise fashion, the decision-making process is decomposed into elements that are tangible and more manageable. The goal is to obtain a more accurate mapping of the user’s preferences than would be obtained if the user were asked simply to assign a score to each criterion under consideration. In addition to removing bias, the process provides better differentiation between factors because the method forces the user to express clear choices.

When performing pairwise comparisons, the user decides which criterion is more important and also grades the relative importance of the two using the 1 through 9 rating scale shown in Table 9. The mathematical algorithms in AHP use these ratings to derive numerical scores that are then used to weight the criteria when their level of effectiveness is evaluated.

One challenge of the pairwise comparisons method is that the choices have to be logically consistent with each other. Even though the process is designed to elicit true stakeholder preferences, in practice it is possible to end up with entries that are logically inconsistent. This possibility is especially likely when the number of comparisons that must be made is relatively large. IRIS includes a test that checks the outcome of the pairwise comparisons for logical consistency. Although the test does not require absolute logical consistency, the entries must meet a reasonable threshold of consistency. If that threshold is not met, an error message is generated and the user is asked to review and edit the comparisons. If the user is unable to

identify and correct the error, a “Suggest Values” option is available to help the user. Selecting “Suggest Values” starts an iterative process that adjusts the user-entered values so that the final values are logically consistent. This option should only be used as a last resort, however, because the evaluation of stakeholder priorities is an important input to the decision analysis modeling implemented in IRIS.

4.2.4 Evaluating the Effectiveness of Each IROPS Investment Initiative

Once the pairwise evaluations have been completed, the user is prompted to rate each mitigation initiative in the IROPS portfolio. An evaluation is required for each criterion in the AHP hierarchy. This evaluation uses drop-down menus to display a modified Likert scale from which the user can select an entry. In a typical Likert scale, a five-step rating scheme is used, as shown in Figure 11.

In IRIS, these choices are replaced with choices that are relevant to the IROPS effectiveness criterion in question. For example, the criterion, “How long will this mitigation initiative take to procure/implement?” is rated using the five options “Very Long,” “Long,” “Average,” “Short,” and “Very Short.”

When evaluating the criteria, more differentiation generally improves the performance of the model. If the mitigations in a portfolio receive evaluations with little variation, cost considerations may dominate the ranking of the portfolio. For this reason, users should not be reluctant in selecting evaluations from the extreme ends of the scale (e.g., “Very Long” or “Very Short” in the example above). The choices should be considered in relation to the scope of the portfolio. If a particular mitigation is better than the rest under any given criterion, it should be a candidate for receiving the highest score in the ranking system.

After all effectiveness criteria have been evaluated, the selections are converted to numerical values from 1 through 5. These evaluations are combined with the weightings computed from the pairwise evaluations to calculate an overall effectiveness score for each mitigation initiative. The effectiveness score is the final input requirement prior to generating the results of the decision analysis.

4.2.5 Ranking the IROPS Investment Portfolio

After all necessary inputs have been provided the results wizard can be used to generate the main output of IRIS—a rank ordering of the investment portfolio. The ranking prioritizes the initiatives using the combined score, which is an assessment of overall economic value that compares the benefit score with the cost score. For each entry in the portfolio, the impact, effectiveness, benefit, and cost scores are shown, along with the lifecycle cost in dollars. These values provide additional information that helps document the ranking of the IROPS mitigation initiatives. For example, the cost scores can help explain whether cost was the dominant factor in ranking the portfolio or whether the lifecycle cost of the highest ranked initiative was outweighed by other considerations, such as impact or effectiveness. A sample summary report with a ranked IROPS portfolio is shown in Figure 12.

In this particular example, lifecycle cost is, in fact, the dominant factor. In this case, the costs of the most expensive alternatives are driven by the recurring cost of the deicing agent over the

○	○	○	○	○
Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree

Figure 11. Typical Likert scale.

Rank	Portfolio		Impact x Effectiveness = Benefit			Cost		Combined	
	Event	Mitigation	Impact Score	Effectiveness Score	Benefit Score	Score	Lifecycle (\$)	Score	Percent
1	Diverted flights due to convective weather	Purchase 2x mobile stairs	0.500	0.463	0.231	0.033	\$221,800	6.969	62.0%
2	Diverted flights due to convective weather	Retrofit Concourse B ground level space int.	0.500	0.537	0.269	0.088	\$586,595	3.062	27.3%
3	Extended tarmac delay due to apron icing	Purchase 1x 20,000 lbs dry chemical spreader	0.500	0.518	0.259	0.345	\$2,304,959	0.751	6.7%
4	Extended tarmac delay due to apron icing	Purchase 2x 4,000 gal liquid deicing trucks	0.500	0.482	0.241	0.534	\$3,569,938	0.451	4.0%

**Figure 12. Sample summary report.**

lifecycle of 10 years. The impact (i.e., severity and likelihood) of the two IROPS events is found to be the same. Although some variation occurs in the benefit score, based on the outcome of the pairwise comparisons and evaluation of effectiveness, this variation is not sufficient to offset the large differences in lifecycle cost among the different initiatives.

Notice that because only cost is measured in dollars, the units for the other scores are arbitrary. For this reason, IRIS normalizes most of the scores so that the values always fall between zero and 1. This normalization process applies to the impact, effectiveness, benefit, and cost scores. The combined score can exceed 1, however, because it is computed as the ratio between the benefit and cost score. As discussed in Chapter 3, the value of the combined score should not be interpreted as a traditional benefit-cost score. In particular, exceeding a value of 1 has no significance. What matters is the magnitude of the combined scores relative to each other. For this reason, the combined score is also expressed as a percentage of the sum of all combined scores across the portfolio. The percentage values can be used to judge how close two competing initiatives are to each other.

The summary report is the main output of the IRIS decision support tool. In addition to the summary report, a number of additional reports are also created. Their purpose is primarily to document the inputs that went into the decision-making process. The reports available in the results wizard include:

- **Portfolio Report:** This report lists the IROPS events and each mitigation initiative in the portfolio. For each mitigation initiative, the specified likelihood and severity are shown.
- **Cost Report:** This report provides the initial and recurring costs for each mitigation initiative, as well as the lifecycle duration in years and the annual cost escalation (expressed as a percentage rate). The lifecycle duration is specified for the entire portfolio, so it is the same value across all mitigation initiatives. The final column shows the total lifecycle cost, which is computed from the other cost inputs.
- **Criteria Report:** This report documents the outcome of the pairwise comparison for each criterion in the three categories in the AHP hierarchy (i.e., strategic challenges, user benefits, and tactical complexity). The report shows the comparison scale for reference. For each pair, the criterion judged to be more important is indicated by a score greater than 1 (as specified by the user). Criteria judged to be equally important are both shown with a score of 1.
- **Effectiveness Report:** This report displays the evaluated level of effectiveness of each mitigation initiative for each criterion in the AHP hierarchy.

The contents of these reports are explained in more detail in the IRIS User Guide (see Appendix B). The reports are generated as standard Microsoft Excel tables, which means they can be exported, printed, copied, or saved using the normal functionality of Microsoft Excel. Preprogrammed buttons for printing and saving also are provided in IRIS for users who are less proficient with Microsoft Excel. Finally, a button is provided to modify the inputs and recalculate the results. This capability supports the generation of alternative cases in which one or more inputs are adjusted, thus providing a basic “What if?” modeling capability. This capability also can be used to conduct sensitivity analyses of the results to any of the inputs used in the decision-making process.



## CHAPTER 5

# Strategic Planning, Financing, and Airport Use Agreements

How to fund IROPS mitigation initiatives is a key consideration in executing an investment plan for mitigating IROPS events. The funding details will depend on many factors, such as airport size, local, state, and federal regulations, budgeting styles of the airport governing body, other budget priorities of the airport, the airport's Capital Improvement Plan, the Airport Master Plan, bond covenants, and Airline Use Agreement (AUA) provisions, to mention a few. These considerations will vary from airport to airport and as conditions change over time. Like most businesses, airports are not static. They adapt and must remain flexible as conditions change while operating subject to regulations, agreements, and practices that are imposed exogenously (on both the airports themselves and on their passengers and tenants) or that they impose on themselves. This chapter describes the processes and considerations for strategic planning for and financing of IROPS mitigation initiatives. It also discusses the relationship between the IROPS investment plan and the structure of the AUAs that the airport has negotiated with its tenants.

### 5.1 Strategic Planning

In general, airports must plan strategically and spend a considerable amount of time and effort on developing long-term plans. The main vehicles for strategic planning activities include the airport's budget, Capital Improvement Plan, Airport Master Plan, and individual project plans. When this planning is undertaken, airport operators must consider not only IROPS needs, but all of the needs of the airport, including ongoing operations, expansion plans, maintenance, replacement, and capital purchases. This planning must also balance the requirement to meet regulatory, statutory, and AUA requirements.

### 5.2 Funding Eligibility

Once the strategic plan has been developed, work on financing can begin. One of the major questions that must be answered is the source of funds. Sources of funds can be internally generated funds, Airport Improvement Program (AIP) funds, passenger facility charges (PFCs), other grants, loans, or bonds. Each of these options is examined within the context of the airport's priorities and financial capabilities. Of specific interest are the eligibility requirements that exist for federal funding programs, which often limit or preclude the application of federal funds to IROPS-related airport improvements.

#### 5.2.1 Internally Generated Funds

Priorities for spending internally generated funds are based on a number of factors. These factors include the structure of the airport's AUAs, the internal policies of the airport governing body, bond reserve requirements, and the nature and market of the airport. The ability of airports

to accumulate funds in excess of their annual requirements for expenditures can vary widely. Some airports can accumulate significant reserve funds, while others are restricted in their ability to do so as a result of their markets and agreements. Most airports have some discretionary funds that are internally generated and internally controlled. Airports may, however, be hesitant to use internally generated funds when other funds, such as AIP and PFC funds, are available. In general terms, it is in the airport's benefit to have a reasonable level of reserve funds to deal with unanticipated needs, including IROPS. Specific levels of reserve funds will depend on the situation of the airport, including the form of the airport's AUAs, its market strength, airline stability, and other factors.

### 5.2.2 Airport Improvement Program/Passenger Facility Charges

The presence of a federal grant program for airport development dates back to the Federal-Aid Airport Program (FAAP) of 1946. In subsequent years, the program has seen many changes as a result of legislation including the Airport and Airway Development Act of 1970, the Airport Development Aid Program, and the FAA Modernization and Reform Act of 2012, which is the current governing legislation.

The two major sources of federal funding for airports are the AIP and PFC programs. For the purposes of this report, the two programs are considered together, as the eligibility requirements are virtually identical with only minor technical differences. Capital projects intended to mitigate IROPS events are generally considered to be unplanned or of an emergency nature, and are considered contingencies in excess of normal FAA design standards. The design standards that apply for AIP- and PFC-eligible projects are intended to accommodate normal conditions, whereas IROPS are considered exceptional or off-nominal conditions. Therefore, most initiatives specifically designed to mitigate IROPS projects are not eligible for AIP or PFC funding. Exceptions include projects whose main benefits extend beyond mitigating IROPS, such as the increase in capacity that a new gate would provide.

Despite the general lack of eligibility for AIP and PFC funding, during the stakeholder outreach phase of ACRP Project 10-14, airports reported examples of having public funds or grants in support of IROPS mitigation. These include grants from agencies not directly associated with the FAA, such as the U.S. Department of Defense or the U.S. Department of Homeland Security (including funding from the Federal Emergency Management Agency). They also include grants from local and state agencies, such as state departments of safety. State and federal surplus property programs also can be used as a resource for equipment intended, at least in part, to mitigate IROPS events. Airports also provided several examples in which AIP- or PFC-funded projects developed to meet FAA standards, also have provided some level of contingency capability for IROPS events.

Table 11 lists typical airport projects and indicates their eligibility for federal funds. In general, eligible projects “include those improvements related to enhancing airport safety, capacity, security, and environmental concerns” (FAA 2012a), but the list is not exhaustive, and each grant application must be judged based on an individual analysis of the request. Federal airport funds can be used for mobile command posts, airport rescue and firefighting equipment, and similar equipment and related facilities in accordance with the Airport Emergency Plan. These resources have clear applications for IROPS events, and the source of funding in no way precludes their use. As airport operators look at their IROPS needs, they commonly find that the purchase of a piece of equipment to address IROPS also supports operational requirements that are fully eligible for federal funding.

In summary, there is some flexibility in the use of AIP and/or PFC funds for purchases of systems that support the primary goals of enhancing airport safety, capacity, security, and

**Table 11. AIP eligibility for a sample of airport projects.**

Eligible Projects	Ineligible Projects
Runway construction/rehabilitation	Maintenance equipment and vehicles
Taxiway construction/rehabilitation	Office and office equipment
Apron construction/rehabilitation	Landscaping
Airfield lighting	Artworks
Airfield signage	Industrial park development
Airfield drainage	Marketing plans
Environmental studies	Maintenance or repairs of buildings
Safety area improvements	Training
Access roads only located on airport property	Fuel farms (may be eligible under specific circumstances)
Removing, lowering, moving, marking, and lighting hazards	Improvements for commercial enterprises
Snow removal equipment and storage facilities	Aircraft hangars (may be eligible under specific circumstances)
Glycol recovery trucks (eligibility subject to specific requirements)	
Aircraft rescue and firefighting equipment (eligibility subject to specific requirements)	
Airport layout plans	
Weather observation stations	
Navigation and visual aids	
Planning studies	
Land acquisition	

environmental concerns. Cross-utilization of equipment owned/operated by the airport and funded with AIP/PFC funds is not prohibited if it is used for a legitimate airport purpose. Specific guidance for airport operators is usually arrived at through consulting with the local FAA Airport District Office or the Airports Division of the applicable FAA Regional Office.

### 5.3 Airport Use Agreements

*ACRP Report 36: Airport/Airline Agreements—Practices and Characteristics* (Faulhaber et al. 2010) focuses on the subject of AUAs. The report explores the complex issues that can arise during the negotiations of AUAs and the definitions and concepts contained in it are also used here. Notice that airports can, and some do, operate their facilities without the benefits of an AUA. For ease of discussion, the term *ordinance* will be used to describe situations where airports and airlines do not operate under an AUA.

An AUA is defined as “the contract between the airport operator and its tenant airlines that establishes the rights, privileges, and obligations for each party and defines how the airport is to be used by airlines” (Faulhaber et al. 2010, 7). AUAs serve the following functions (Faulhaber et al. 2010, 7):

- Establish the business arrangement and rate-setting methodology with the airlines (e.g., compensatory, hybrid, residual).
- Identify the premises and facilities leased by the airlines and define the degree of control by the lessee (e.g., exclusively leased, preferentially leased, leased in common, etc.).

- Define the level of control over the expenses at the airport, if any (typically capital expenses are those over which the airlines may have some control through a majority-in-interest or similar type provision).
- Identify general party responsibilities and obligations for indemnification, insurance, environmental issues, and other governmental inclusion.

According to Faulhaber et al. (2010, 8), AUAs in effect at airports today generally follow one of three different rate-setting methodologies:

A pure *residual* methodology is where the airlines bear the overall financial risk for the airport's operation and, in turn, receive the benefit of all non-aeronautical revenue credited toward the calculation of their rates and charges. On the opposite side of the spectrum, a pure *compensatory* rate-making approach is where the airport operator assumes the overall financial risk for the airport operation. There is also a third approach, generally called a *hybrid* methodology, that is a mixture or combination of the prior two approaches and may include a "revenue sharing" component of excess non-airline revenues generated at the airport.

Airports operating by ordinance will have many similar provisions in their ordinance to those that are found in AUAs, the primary difference being that the establishment of the ordinance provisions is by the airport's governing body and not negotiated with the airlines. These airports will select a rate-setting methodology and use it to develop a schedule of rates and charges.

As airport operators develop their AUAs, the provisions within those agreements or ordinances will influence how they approach the financial consequences of IROPS mitigation initiatives. Given that AUAs and ordinances vary substantially by airport, however, it is not possible to determine a specific financial outcome for any specific IROPS mitigation strategy without running an airport's model for setting rates and charges.

## 5.4 Leased Facilities

An airport's AUA contains provisions that govern use of the airport's facilities. These provisions will, in part, affect the planning for and funding of IROPS mitigation strategies. Historically, airports and airlines entered into long-term AUAs. Often the AUA term was tied to, or paralleled, the issuance of long-term debt instruments referred to as general airport revenue bonds, commonly issued for periods up to 30 years. Over time, for various reasons, these practices have changed in favor of shorter-term AUAs. Today, AUAs commonly have 5-year terms (with extensions) and less commonly have terms as short as 30 days on a rolling basis.

In the context of this report, the most common concern relates to the leasing of gate space, including the associated apron area, boarding bridge, and passenger holding areas. Other airport facilities, such as cargo buildings, cargo aprons, areas for Federal Inspection Services, and hardstands are also of concern, but the issue of control is the same. Within AUAs, the terms of use are commonly described and resolved in one of three general fashions: (1) the space is leased to the tenant for its exclusive use, (2) the space is leased to the tenant on a preferential use basis, or (3) the space is leased on a common use basis. The following paragraph summarizes current trends (Faulhaber et al. 2010, 48):

The shift away from exclusive use gates, along with the adoption of compensatory pricing practices for terminal space, which tend to be higher than residual rates, serves to emphasize the effective use of these facilities. Also, the financial pressures placed on the airlines reduced their ability to absorb costs for under-utilized assets. Thus, with the exception of a few airports that have significant grants of exclusive gates remaining, gate assignment provisions have generally shifted in a manner that provides greater control to the airport operators.

As described in more detail below, each of the three methods has advantages and disadvantages. The focus of the discussion is on how the lease structure can affect the implementation of IROPS mitigation initiatives.

### 5.4.1 Exclusive Use

Exclusive use agreements place control of the leased facility on the entity that is granted the exclusive use of the facility. Although this is a strong position for the leaseholder, there may be opportunities for the airport operator to negotiate use of gate space during periods of non-use. Generally, airports and airlines are reluctant to open an AUA negotiation on issues during the term of an AUA, but negotiating side agreements to address specific issues outside the AUA is common. For example, the airport operator and the airline leaseholder may be able to negotiate the use of an exclusive space under specific and mutually agreeable terms, such as during IROPS events.

### 5.4.2 Preferential Use

Each signatory to the AUA may be granted preferential use of specific space. The basic operating practice is that the signatory airline has priority (preferential) access to the space, but not exclusive use. In application, use of the defined space is flexible when it does not materially affect the operations of the tenant holding the preferential use right to the space. Commonly, the airport and lease holder will develop understandings about preferential use in writing. The details generally are described in documents outside the AUA, although doing so is not required. Preferential use agreements generally give added flexibility to airport operators to respond to IROPS events, as they can maximize the use of unused space.

### 5.4.3 Common Use

The term *common use* denotes space that is used by airlines on a non-exclusive or non-preferential basis (e.g., gates, apron areas, hold rooms, and passenger processing equipment). A common example of this type of arrangement is the use of baggage delivery areas and associated baggage belts and/or carousels. The use of facilities in common with other users generally provides the most efficient use of space and related facilities. The effective and flexible use of space does, however, come with higher system management commitments. For example, the airport operator typically is responsible for scheduling the use of the common use facilities. This responsibility can be challenging during IROPS events, given their disruptive and unpredictable nature.

### 5.4.4 Limitations and Opportunities

As related to terminal and apron space, preferential use and common use agreements provide greater opportunities for use of space during IROPS events than do exclusive use agreements, even when side agreements are in place. Still, each airport is different and needs to undertake a critical review of its operations to determine the order of magnitude and the consequences of each type of IROPS event that is likely to occur. Best management of leased facilities must balance cost, real availability of the space, and effectiveness. The IRIS decision support tool developed for ACRP Project 10-14 should help airport operators conduct these reviews, keeping in mind that no single, best answer exists given the many factors that must be considered.

## 5.5 Rates and Charges

A complete discussion of rates and charges is outside the scope of this document and is well covered in *ACRP Report 36*, at least in the context of AUAs. Within the context of business planning for IROPS mitigation initiatives, however, the effect on rates and charges will be important for airport operators to understand. Given that rate-setting varies substantially from airport to airport, it is not productive to attempt to define standard practices, conventions, or general

effects that IROPS-related expenses will have on rates and charges. The ease of calculating the effect of any related capital or O&M expenses on rates and charges is proportional to the complexity of the rate-making process used by the airport. The level of complexity, in turn, is affected by the provisions in the AUA, bond covenants (if applicable), airport stakeholder preferences, and legal and regulatory provisions, including FAA policies. Where expenses are included in the calculation of the rate base, they are likely to be considered when evaluating each potential initiative. Depending on the provisions contained in the AUA, airports also may be required to consider majority-in-interest (MII) provisions (see Section 5.6).

## 5.6 Majority-In-Interest

As MII provisions affect an airport's ability to fund projects, they must be considered when present in an airport's AUA. The AUA's role in defining control of capital projects can be summarized as follows (Faulhaber et al. 2010, 58):

Capital project control and consultation is typically an issue that will surface in most Agreement negotiations between airlines and airport operators. Some Agreements address this issue through an MII provision. This provision will generally indicate how much control (if any) the signatory airlines have over an airport operator's capital development program, and will detail the formal procedures for how such controls are executed. Capital project control and consultation provisions vary considerably, ranging from no control to very strict and structured airline control. There are also numerous variations in between. Since the airlines bear the financial risk, more airline capital development control generally occurs as Agreements become more residual in nature.

There is no right or wrong answer and no good or bad MII provision. Each AUA/MII must fit the issues relevant to the airport/airline(s). Airport operators also understand that AUAs (and subsequently MII provisions) come into consideration only when they impact a signatory to the agreement. Should an airport decide to expend funds on a project and not seek reimbursement via rates and charges collected from the signatory airline(s), it is generally within the airport's discretion to take that action unless prohibited by some other provision in the AUA, bond covenants, or restrictions.



## CHAPTER 6

# Lessons Learned

This chapter describes lessons learned during the development of the decision-making approach and accompanying decision support tool. The focus is on lessons that have applicability to users of the guidebook and IRIS, although some avenues for future research are also noted.

ACRP Project 10-14 included a substantial outreach component, to ensure that the objectives and implementation matched the needs of the airport community. The outreach effort consisted of the following components:

- A stakeholder survey distributed electronically to a broad range of airports.
- Structured one-on-one telephone interviews with a select group of representative airports.
- A demonstration project that fielded a prototype version of IRIS at three airports, including one-on-one familiarization sessions.

Feedback received from the outreach effort is the primary source of the conclusions and recommendations described here. The findings also reflect the outcome of internal testing of IRIS. Additional information about the research involved in ACRP Project 10-14 is available on-line at [www.trb.org](http://www.trb.org) by searching “ACRP Project 10-14.”

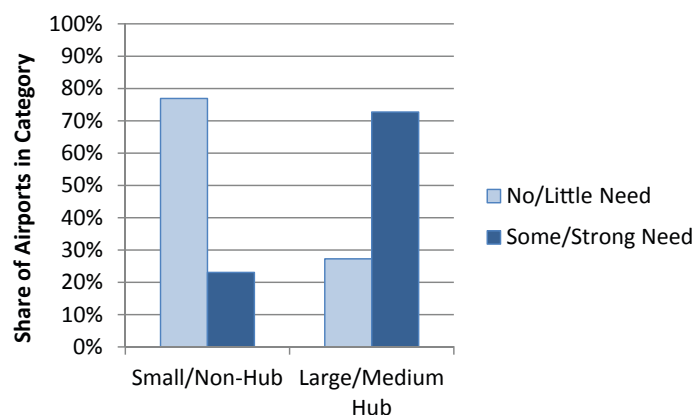
### 6.1 IROPS Business-Planning Needs

As part of the survey effort, airports were asked to rate their need for a formal business-planning process for IROPS-related investments. As shown in Table 12, the survey responses confirmed the need for an IROPS business-planning approach. The perceived need varied by airport size, however, with larger airports more likely to express a need for formal methods (see Figure 13). At least in part, this result appears to be due to the tendency of smaller airports to favor low-cost solutions, including for tasks such as coordination and planning activities involving an airport’s own staff.

Notice that even for mitigation initiatives that rely entirely on the use of airport staff time, IRIS can be used to prioritize investments. Examples include the development of contingency plans, coordination with airport tenants, planning studies, and negotiations with external providers of equipment such as shuttle buses, food, rental equipment, and so forth. In such cases, the cost associated with the initiative would be the marginal cost of the labor hours used. As an approximation, this cost could be estimated as the average hourly salary multiplied by the expected number of hours required. The evaluation of effectiveness would be measured as normal and would not differ from the case of an initiative involving construction or acquisition.

**Table 12. Survey responses on need for IROPS business-planning approach.**

	Non-Hub/ General Aviation Airport	Small Hub Airport	Medium Hub Airport	Large Hub Airport	Total
No need	3	1	0	0	4
Little need	13	3	1	2	19
Some need	3	2	3	4	12
Strong need	0	1	0	1	2

**Figure 13. Need for IROPS business-planning approach by airport size.**

## 6.2 Impact of Funding Availability

As described in Chapter 5, for the purposes of funding eligibility, IROPS are considered exceptional conditions. Consequently, IROPS-related investments are generally not eligible for AIP or PFC funding. To study this issue, the ACRP Project 10-14 outreach effort included survey questions on the effect of funding availability on IROPS-related investment decisions. The results are shown in Table 13.

Approximately two-thirds of survey recipients acknowledged “Some Effect” or a “Strong Effect” of the availability of AIP or PFC funds. To address this issue, the evaluation of effectiveness in IRIS takes into account the impact of the availability of funding. The category “Strategic Challenges” in the decision hierarchy includes “Funding Availability” as a criterion. For airports

**Table 13. Survey responses on effect of availability of funding.**

	Non-Hub/ General Aviation Airport	Small Hub Airport	Medium Hub Airport	Large Hub Airport	Total
No effect	2	0	0	1	3
Little effect	7	2	0	0	9
Some effect	6	3	2	4	15
Strong effect	4	2	2	2	10

**Table 14. Survey responses on need for/value of decision support tool.**

	Non-hub/General Aviation Airport	Small Hub Airport	Medium Hub Airport	Large Hub Airport	Total
No	2	0	0	0	2
Little need/value	5	2	0	2	9
Some need/value	9	4	3	2	18
Strong need/value	3	1	1	3	8

that wish to reflect that funding availability has a strong impact, this criterion should be rated as important relative to other criteria in the pairwise evaluation. The model uses the question, “How accessible will funding be for this initiative?” to quantify this effect. The responses for each initiative under consideration are incorporated in the ranking of the IROPS investment portfolio. The extent to which funding availability contributes to the final result is determined by the relative importance assigned to this criterion in the pairwise evaluation.

### 6.3 Need for an IROPS Investment Decision Support Tool

Measuring the perceived need for and value of an IROPS investment decision support tool was of particular interest to this research project. Airport stakeholders’ perceived need for such a tool was assessed both prior to and after the development of IRIS. The survey, which occurred early in ACRP Project 10-14, included a description of the basic features of IRIS. Airports were asked to rate their perceived need for the described decision support tool. The results are summarized in Table 14. The assessment of the demonstration project also included several questions intended to evaluate the perceived value of IRIS. The responses to those questions are shown in Table 15.

More than two-thirds of the survey respondents indicated “some need/value” or a “strong need/value” for a decision support tool for IROPS investment analysis. Responses from the structured interviews suggested that having empirical data to support investment decisions could help diminish political and subjective appeals in the decision-making process. The value of the tool was confirmed by the feedback received during the formal assessment of the post-implementation demonstration project. The demonstration project only included three airports but all three confirmed the need for the tool. Specifically, the assessment demonstrated that the airports found IRIS to be usable and that the results were pertinent to their IROPS business-planning needs.

**Table 15. Demonstration project feedback—overall value of IRIS.**

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
This tool would add value to the IROPS business-planning needs of my airport.				2	1
The tool provides useful results.				3	
Overall I was satisfied with the usability of this tool.				3	
I would likely use a tool like this for future IROPS business planning.				2	1

## 6.4 Implementing Pairwise Comparisons

A component of AHP and its implementation in this project is the pairwise comparison of evaluation criteria. The purpose of these comparisons is to elicit the user's preferences to ensure that the decision is weighted toward factors that are deemed important. The advantages of using pairwise comparisons are described in Chapter 3. In summary, their use assists in deriving clear preferences by reducing bias and by providing better differentiation.

A challenge with the use of pairwise evaluations is that they must be logically consistent for the AHP methodology to function correctly. Consider, for example, the following three criteria in the category "Tactical Complexity" (TC):

- **TC1:** Disruption level during implementation.
- **TC2:** Execution response time.
- **TC3:** Policy and regulatory compliance.

If the user specifies that TC2 is more important than TC1 and that TC3 is more important than TC2, then it can be inferred that TC3 is more important than TC1. If, however, the user specifies in IRIS that TC3 is less important than TC1, the comparisons are not logically consistent and an error is generated.

In practice, the check for logical consistency is not absolute. Because each pairwise comparison includes a score indicating relative importance, the validation test in IRIS is based on a consistency ratio computed from these scores. This ratio quantifies the extent to which the pairwise comparisons are logically consistent. The consistency ratio cannot exceed a specific error threshold. If the error threshold is exceeded, the user is prompted to repeat the pairwise evaluation.

Even though the pairwise comparison is meant to reveal the user's real preferences, internal testing and the airport demonstration project showed that errors in logical consistency occurred periodically. If the pairwise comparison involves a relatively small number of criteria, it is a relatively easy task for the user to review the choices and manually correct the inconsistency. This is the case in the example provided using TC1, TC2, and TC3, which involved only three pairwise comparisons. If the number of criteria is large, however, it can be relatively difficult to scan the choices and identify the error. This is the case for the categories "Strategic Challenges" and "User Benefits," which require six pairwise comparisons each.

To prevent a frustrating user experience, changes to the IRIS decision support tool were implemented during the demonstration phase to improve the validation of the pairwise comparisons. Multiple criteria are compared against each other, so it is not possible to have the software identify which particular pair is causing a logical inconsistency. Instead, a feature was added to allow for an adjustment of the user's inputs to meet the consistency ratio threshold. This feature is implemented using the "Suggest Values" button. Activating this feature starts an iterative process in which the values are incrementally adjusted until the threshold is met. The user then reviews the suggested values and confirms their use. In addition, the consistency ratio threshold was relaxed slightly to reduce the frequency of logical inconsistencies.

Although the changes described in this section were found to improve the user experience, they come at the price of potentially losing fidelity in the assessment of user preferences. For this reason, the "Suggest Values" feature is intended to be used as a last resort. Other methods for improving the pairwise evaluation process should be investigated for future application of pairwise comparisons in this or similar decision support tools.

## 6.5 Evaluating Non-Economic Benefits

A distinct strength of the AHP-based methodology presented here is its ability to quantify benefits and compare them against costs without assigning monetary values to the benefits. In investment decisions evaluated using traditional benefit-cost analysis, it is common to have both benefits that can be monetized and those that cannot; however, the latter can usually only be described qualitatively by including a narrative describing the benefits. This is because the benefit-cost analysis depends on comparing monetized benefits against lifecycle costs. Both benefits and costs must be expressed in monetary terms.

An example of benefits that generally cannot be monetized is the reduction of greenhouse gas (GHG) emissions. If a proposed enhancement would result in fuel savings over the baseline legacy case, GHG emissions would also be reduced. Although the reduction in the amount of GHG can usually be modeled, there is no FAA-approved methodology for monetizing the resulting benefit. The modeled reduction in GHG could be included as part of the benefits narrative, but it would not affect the calculation of the benefit-cost ratio or the other common metrics used to evaluate the business case. Only the cost of the fuel saved would be included on the benefits side of the benefit-cost ratio.

In an AHP-based methodology, however, GHG emissions could be one of the criteria included in the hierarchy. This would allow for a quantitative comparison of the proposed enhancement against the baseline case. It may be possible to incorporate AHP as a supplemental methodology when conducting benefit-cost analyses, as this may allow for a broader range of criteria to be incorporated in the business case.

## 6.6 Conclusions

The feedback from the airport community obtained during the course of ACRP Project 10-14 confirms the original research need: Demand exists for a business-planning and decision-making approach to prioritize IROPS-related funding. Although best practices have been established for business case analysis, including some airport applications, business planning for IROPS mitigation has not been adequately addressed. This project has resulted in the initial development of such an approach. This approach addresses the special challenges of business planning for IROPS events, including the combination of potentially severe impacts and unusually high levels of uncertainty.

The approach presented in this guidebook draws on decision theory, including the AHP methodology. As implemented in the decision support tool IRIS, this methodology has several strengths:

- It allows for rapid business case analyses of IROPS mitigation initiatives.
- It requires no background or training in decision theory or business case analysis.
- It combines subjective evaluations with objective business case analysis metrics.
- It uses pairwise evaluations to break down complex decisions into more manageable ones.
- It is able to quantify intangible benefits that usually are included only as a qualitative narrative.

At the same time, the development of the approach unearthed several challenges. Notable among these is the implementation of pairwise evaluations in a user interface like the one developed for IRIS. These challenges serve as the starting point for areas suitable for future research. Potential research topics include:

- Managing bias and differentiation in decision support techniques that rely on subjective input.
- Applying decision theory and related methodologies like AHP to other areas of airport planning and administration.

- Applying decision theory to supplement traditional business case analysis methodologies, with a focus on AHP's ability to quantify intangible benefits.
- Increasing the utility of the IRIS application without sacrificing the analytical underpinnings of the approach, including improving the process for conducting pairwise comparisons.
- Investigating alternative methodologies for IROPS-related business planning.

The demonstration project confirms the utility and perceived value of the IRIS decision support tool. IRIS could, however, be evolved and upgraded, using feedback from airports as they begin to use the tool to assist in their investment planning process. Updating the tool would further improve its effectiveness by incorporating knowledge gained from a broader range of users and investment portfolios.



## References

- Faulhaber, J. et al. 2010. *ACRP Report 36: Airport/Airline Agreements—Practices and Characteristics*. Transportation Research Board of the National Academies, Washington, D.C.
- Federal Aviation Administration. 1999. *FAA Airport Benefit-Cost Analysis Guidance*. Washington, D.C.
- Federal Aviation Administration. 2010. *Airport Emergency Plan*. Advisory Circular 150/5200-31C. Washington, D.C.
- Federal Aviation Administration. 2011. “Airport Improvement Program: Modifications to Benefit Cost Analysis (BCA) Threshold.” *Federal Register*, Vol. 76, No. 205 (October 24, 2011), pp. 65769-65772.
- Federal Aviation Administration. 2012a. *Overview: What is AIP?* Available at: <http://www.faa.gov/airports/aip/overview/> (as of January 23, 2013).
- Federal Aviation Administration. 2012b. *Safety Management System for Airports*. FAA Advisory Circular 150/5200-37A (draft). Washington, D.C.
- Federal Aviation Administration. 2013a. *Business Case Analysis Guidance*. Washington, D.C.
- Federal Aviation Administration. 2013b. *Economic Information for Investment Analysis*. Available at: <http://www.ipa.faa.gov/Tasks.cfm?PageName=Economic%20Analysis> (as of April 25, 2013).
- Landau, S., and G. Weisbrod. 2009. *ACRP Synthesis 13: Effective Practices for Preparing Airport Improvement Program Benefit-Cost Analysis*. Transportation Research Board of the National Academies, Washington, D.C.
- Marsh Risk Consulting. 2012. *ACRP Report 74: Application of Enterprise Risk Management at Airports*. Transportation Research Board of the National Academies, Washington D.C.
- Nash, J. M. et al. 2012. *ACRP Report 65: Guidebook for Airport Irregular Operations (IROPS) Contingency Planning*. Transportation Research Board of the National Academies, Washington, D.C.
- Office of Management and Budget. 2013. *Analytical Perspectives: Budget of the U.S. Government*. Available at: [http://www.whitehouse.gov/omb/budget/Analytical\\_Perspectives/](http://www.whitehouse.gov/omb/budget/Analytical_Perspectives/) (as of October 21, 2013).
- Saaty, T. L. 1980. *The Analytic Hierarchy Process*. McGraw-Hill Book Co., New York, N.Y.
- Trejos, N. 2012. “Airline Tarmac Delays up in July, Government Reports.” *USA Today*. Available at: <http://travel.usatoday.com/flights/story/2012/09/17/airline-tarmac-delays-up-in-july-government-reports/57794470/1> (as of September 18, 2012).
- U.S. Department of Transportation. 2012a. *Enhancing Airline Passenger Protections*. Second Final Rule, 14 CFR Parts 234, 253, 259, and 399.
- U.S. Department of Transportation. 2012b. *Submission of U.S. Carrier and Airport Tarmac Delay Contingency Plans to Department of Transportation for Approval*.
- U.S. Government Accountability Office. 2009. *GAO Cost Estimating and Assessment Guide: Best Management Practices for Developing and Managing Capital Costs*. GAO-09-3SP.

## APPENDIX A

# Business Case Analysis Primer

The purpose of this primer is to present a high-level introduction to the key concepts of business case analysis in a way that is meant to be understandable to someone who may not necessarily have any formal business case analysis training. The reason for developing a business case is to justify the resources or capital investment necessary to implement an initiative. Business case preparation is intended to ensure that acquisition preparations are complete to ensure that the airport sponsor receives maximum value for the resources expended.

A typical business case analysis begins with identifying a shortfall or technological opportunity. This is followed by the development of one or more strategies for replacing, upgrading, or enhancing the existing operational and technical environment. The next steps are to determine the costs, benefits/effectiveness, risks, and schedule of implementing the initiative(s) and to perform an economic analysis based on those inputs. The economic analysis compares the benefits and the costs for the lifecycle of each initiative, and measures the overall economic value of the investment in terms meaningful to decision makers. The generally accepted industry practice is to use benefit-cost ratio and net present value (NPV) as standard criteria for judging the lifecycle economic value of a program, although other metrics exist that can be used for this purpose as well.

The regulatory requirement for airports to conduct benefit-cost analyses generally is triggered only when \$10 million or more in AIP discretionary funding is requested (FAA 2011, p. 65769). As a result, the majority of airport projects never trigger the formal requirement. Nonetheless, the principles related to business case analysis described in this document generally still apply to investment decisions made by airport sponsors, even if the formal process is not required.

The remaining sections of this document further describe the key concepts of business case analysis including project lifecycle, cost estimating, benefits analysis, risk adjustment, and determination of the overall economic value. Additional references are provided at the end of this document should the reader want to explore these concepts in more detail.

## The Project Lifecycle

Selection of an appropriate project lifecycle enables costs and benefits of various alternatives to be evaluated objectively. Project requirements play a large part in determination of the lifecycle. When the requirements are ongoing in nature, a lifecycle end must still be

**A-2** Being Prepared for IROPS: A Business-Planning and Decision-Making Approach

assigned. Here, the physical life of the asset comes into play. A runway, airport terminal, or bus may vary considerably in durability. Selection of an evaluation period long enough to account for the increasing maintenance costs and periodic tech refresh costs is important. Where a business case analysis is undertaken comparing different technologies with different longevities, a compromise intermediate lifecycle period is typically suggested. Lifecycle periods of between 10 and 20 years are most common for airport projects.

### **Cost Estimating**

Cost estimating is a dynamic process, encompassing interdependencies and integration with system engineering, benefit analysis, requirements, risks, schedule, implementation planning, etc. Lifecycle cost estimates include the total costs to acquire, implement, operate, maintain, tech refresh, and dispose of the proposed acquisition. Lifecycle cost estimates are constructed depicting the potential future initiative using a lifecycle commensurate with the benefits so an economic analysis can be easily performed. The elements of the cost estimates include costs for both capital and operations and maintenance (O&M) expenses. The organization of cost elements in a cost estimate is called the work breakdown structure (WBS), which is useful because it standardizes the way costs are grouped and presented across various alternatives.

The following items illustrate the typical steps for a cost estimate, recognizing that each step may be adjusted as the estimate matures:

- Identify the purpose and scope of the cost estimate for each alternative.
- Establish general ground rules and assumptions.
- Develop the cost-estimating structure by WBS element.
- Collect and evaluate cost, schedule, and technical data.
- Identify, select, and calibrate (or modify) estimating methods.
- Develop a point estimate and phase costs by fiscal year.
- Identify, evaluate, and adjust for risk and uncertainty.

As a final step, the cost estimates are fed into the overall economic analysis to determine the overall economic value of each alternative. More details on defining and quantifying project costs are documented in the FAA's airport-specific guidance for benefit-cost analyses (FAA 1999).

### **Benefits Analysis**

Benefits analysis is the process of identifying the physical or operational values of the goods or services that an initiative will yield over the analysis period. These values are usually defined in physical or operational units (metrics) or in terms that represent enhanced functionality (e.g., reduced aircraft delays, fuel or time saved, or more flights handled per controller), which can then be quantified (FAA 2013a). They can also be qualitative in nature if quantification is not feasible.

A general classification of benefit categories may include cost effectiveness, safety, efficiency, and environment. Each of these categories will be discussed further below. Notice that this is a general classification that can be applied to any benefits analysis, but it does not necessarily follow that each initiative is predicted to achieve benefits in each of these four categories. This is particularly true for IROPS mitigation initiatives, which, for example, are rarely expected to have environmental benefits.

Cost Effectiveness refers to benefits that reduce the airport sponsor's costs or increase labor productivity. Cost-related benefits are measured either as potential cost savings or cost avoidance. Benefits in productivity and efficiency can be measured using a variety of metrics, for example as labor costs monetized using compensation information for employees.

Safety refers to benefits that lower the risk of accidents and errors. Safety benefits are typically measured either as a potential reduction in the number or severity of accidents or a decrease in operational errors. Safety-related benefits can be monetized in several different ways. One metric used when the risk of accidents is predicted to decrease, is to consider hull replacement costs, as well as the economic value of fatalities and injuries identified per International Civil Aviation Organization injury classifications.

Efficiency refers to benefits that improve aircraft operators' financial performance, particularly aircraft operating costs. It also refers to benefits that affect passengers' opportunity costs, monetized through the economic value of time spent traveling. Standard data for the value of travel time is published by U.S.DOT policy, including a methodology for accounting for real growth in income. Finally, in applications where fuel savings are expected beyond those associated with reduced travel time, there is the potential for additional benefits monetized using an average unit fuel cost applied to the quantity of fuel saved.

Environment refers to benefits that affect the environment. Typical benefits include decreased noise impact, improved air quality, and reduced emissions of greenhouse gases (GHG). Although there is no FAA-adopted methodology for monetizing GHG emissions reduction for the purposes of a business case analysis, CO<sub>2</sub> reduction is often used as a quantitative proxy for total GHG reduction.

Based on analysis of the above (or similar) categories, the identified benefits are monetized for each year in the lifecycle. The benefits estimates are then fed into the overall economic analysis to determine the overall economic value of each alternative. Some observed practices for quantifying benefits are presented in *ACRP Synthesis 13: Effective Practices for Preparing Airport Improvement Program Benefit-Cost Analysis* (Landau and Weisbrod 2009). Additionally, standard economic values used by the FAA Air Traffic Organization to monetize benefits from the categories above are published annually by the Office of Investment Planning and Analysis (FAA 2013b).

## **Risk Adjustment**

Business case risk analysis is an objective evaluation of the proposed investment to determine the probability that an undesirable event will or will not occur during implementation and the significance of the consequence of that occurrence or nonoccurrence. Risk analysis

**A-4** Being Prepared for IROPS: A Business-Planning and Decision-Making Approach

provides methods for incorporating the uncertainty inherent in all predictions. Generally, three methods are used (Landau and Weisbrod 2009):

- Sensitivity analysis, where variations in the results are observed by changing one or several input variables at a time
- Probabilistic methods, where distributions are applied to some or all input variables and sampling techniques are used to determine distributions surrounding the resulting metrics
- Scenario-based methods, where “low,” “medium,” and “high” scenarios incorporate varying degrees of pessimism or optimism about growth in demand or savings associated with future projects

### **The Business Case: Lifecycle Economic Value**

Most airport investments involve the expenditure of large blocks of resources at the outset of the project in return for an annual (usually rising) flow of benefits to be realized in the future. Although these benefits and costs are in the form of dollars, year-to-year benefits and costs cannot simply be summed into totals and then compared. Rather, the analyst must take into account the fact that dollars paid out or earned in the near-term are worth more in “present value” than are dollars paid out or earned in the far-term. This procedure establishes whether or not benefits exceed costs for any or all of the alternatives (thus indicating whether or not the objectives should be undertaken) and which alternative has the greatest NPV. The process of converting future cash flows into present value is called discounting.

The opportunity cost of money accounts for the need to discount dollar amounts to account for the passage of time. The opportunity cost of capital reflects the fact that, even without inflation, the present value (the value today) of a dollar to be received a year from now is less than the value of a dollar in-hand today. A dollar in-hand can be invested immediately in an interest-bearing account (or some other investment instrument) and earn interest for a period of one year. A dollar to be received one year from now cannot earn income for the investor during this period.

Discounting requires the division of an annual discount rate into future benefits and costs. The annual discount rate (also known as the marginal rate of return of capital) represents the prevailing level of capital productivity that can be achieved at any particular time by investing resources, i.e., the opportunity cost. Because the FAA recommends the use of constant dollar cash streams, the discount rate should be net of inflation. This net-of-inflation rate is called the real discount rate. The real discount rate relevant to all airport projects to be funded with federal grant funds is set at 7% (FAA 2013b).

The present value of incremental costs and benefits can be compared in a variety of ways so as to determine which, if any, option is most worth pursuing. In some cases, no alternative will generate a net benefit relative to the base case – a finding that would argue for pursuit of the base case scenario. The following are the most widely used present-value comparison methods: NPV, benefit-cost ratio, internal rate of return, and payback period.

**Net Present Value:** NPV is defined as the difference between the present value of cash inflows (benefits) and the present value of cash outflows (costs). The NPV method requires that an alternative meet the following criteria to warrant investment of funds:

- Have a positive NPV.
- Have the highest NPV of all tested alternatives.

The first condition insures that the alternative is worth undertaking relative to the base case, i.e., it contributes more in incremental benefits than it absorbs in incremental costs. The second condition insures that maximum benefits (in a situation of unrestricted access to capital funds) are obtained. NPV is the most widely used and theoretically-accurate economic method for selecting among investment alternatives. NPV does have certain conceptual and analytical limitations, however, which make consideration of other present-value evaluation methods appropriate in some instances.

**Benefit-Cost Ratio:** The benefit-cost ratio is defined as the present value of benefits divided by the present value of costs. A proposed activity with a ratio of discounted benefits to costs of one or more will return at least as much in benefits as it costs to undertake, indicating that the activity is worth undertaking. The principal advantage of the benefit-cost ratio is that it is intuitively understood by most people. Moreover, this method provides a correct answer as to which objectives should be undertaken (i.e., those with ratios greater than or equal to unity). However, this method often fails to answer correctly the question of how to accomplish the objectives most effectively, particularly when comparing mutually exclusive projects of different scale or different levels of capital intensity and operating expense.

**Internal Rate of Return:** The internal rate of return (IRR) is defined as that discount rate which equates the present value of the stream of expected benefits in excess of expected costs to zero. In other words, it is the highest discount rate at which the project will not have a negative NPV. To apply the IRR criterion, it is necessary to compute the IRR and then compare it with OMB-prescribed 7% discount rate. If the real IRR is less than 7%, the project would be worth undertaking relative to the base case.

The IRR method is effective in deciding whether a project is superior to the base case, but it is difficult to utilize for ranking projects and deciding between mutually exclusive alternatives. It is not unusual for a project ranking established by the IRR method to be inconsistent with those of the NPV criterion. Moreover, it is possible for a project to have more than one IRR value, particularly when a project entails major final costs, such as clean-up costs. Although the literature on capital budgeting contains solutions to these problems, these solutions are often complicated or difficult to employ in practice and present opportunities for error.

**Payback Period:** The payback period measures the number of years required for net undiscounted benefits to recover the initial investment in a project. One characteristic of this evaluation method is that it favors projects with near-term (and more certain) benefits. However, the payback period method fails to consider benefits beyond the payback period. Nor does it provide information on whether an investment is worth undertaking in the first place.

More information on these concepts as well as the formulas for all of the techniques and metrics described above can be found in the FAA's guidance on conducting benefit-cost analyses for airport projects (FAA, 1999). Notice, however, that the focus of the FAA guidelines is on capacity-enhancing projects, because these are the most likely to trigger the project cost threshold for requiring a benefit-cost analysis.



## APPENDIX B

# IRIS User Guide

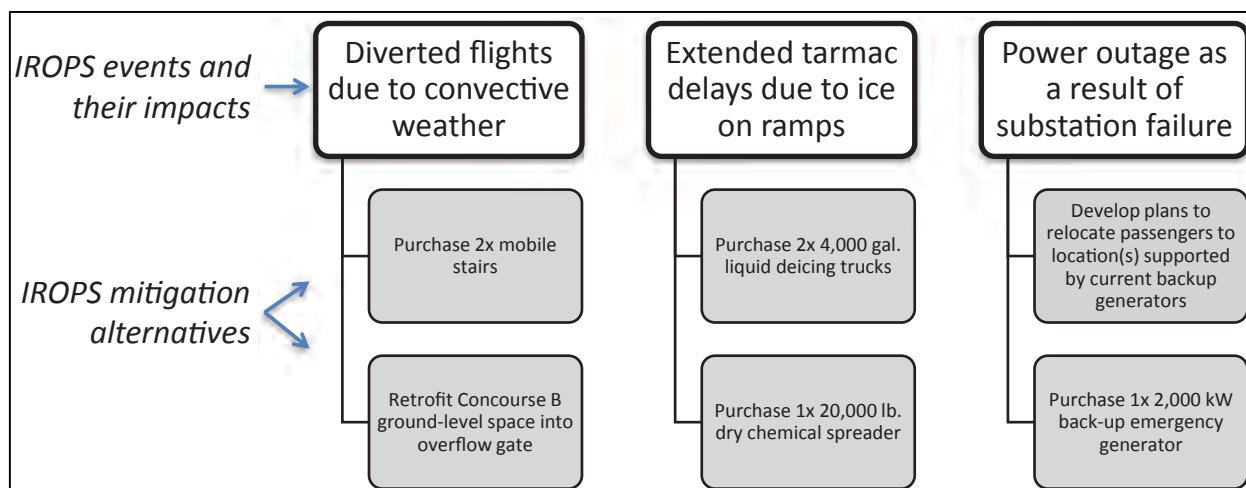
## Introduction

Irregular operations (IROPS) present challenging planning problems for airports since they inherently include a large amount of unknown factors and have the potential to severely disrupt operations. The Airport Cooperative Research Program (ACRP) has funded the development of a decision support tool to help airports prioritize funding decisions to mitigate IROPS impacts. The software is implemented as an Excel-based program titled the IROPS Investment Support tool, or IRIS for short. This User Guide gives you the basics to use IRIS. It will introduce you to the concepts underlying IRIS, explain how to navigate through the tool's features, and show how results are presented and are to be interpreted. A checklist of information that should be compiled prior to running IRIS is provided in the section "Getting Started."

## Background

Investment planning for IROPS events is difficult due to their potentially significant impact and disruptive nature. They can also be quite rare and difficult to predict. Traditional business case analysis that estimates the costs of an initiative and compares those to monetized benefits is not well-suited to IROPS challenges. IRIS uses an integrated approach that merges decision analysis with traditional benefit-cost methodologies, in order to provide a comprehensive evaluation of the impact, effectiveness and costs of potential investments in IROPS mitigation initiatives. Note that the tool cannot capture all issues that affect an investment decision and does not attempt to replace an airport's judgment of what strategy to pursue. However, the tool provides an analysis of potential benefits to airport stakeholders, including a broad spectrum of the financial, tactical, and strategic considerations related to the possible mitigation alternatives.

IRIS allows the airport management team (the intended user of IRIS) to specify which IROPS events and potential impacts for which they would like to plan. IRIS provides decision support for evaluating the effectiveness of associated potential mitigation initiatives. The user defines the potential mitigations under consideration by creating a so-called "investment portfolio" of mitigation initiatives. The initiatives should match the IROPS events and the impacts they are designed to address. A sample investment portfolio is provided in Figure B.1.

**B-2** Being Prepared for IROPS: A Business-Planning and Decision-Making Approach

**Figure B.1.** Sample investment portfolio for IROPS mitigation initiatives.

The user then provides additional input to help evaluate the likelihood, impact, effectiveness, and cost associated with the IROPS events and the associated investment portfolio. IRIS processes the user input and uses a decision analysis methodology known as the analytic hierarchy process (AHP) to generate a ranking of the IROPS mitigations in the portfolio, which can be used as guidance on which options would be most effective to fund.

AHP is an established, structured decision analysis technique. It merges the stakeholder's objectives with their evaluation of the problem to provide insight on complex problems in a prescribed way. The process involves breaking the problem into manageable parts and arranging them in a logical hierarchy. Then, by making simple comparisons between the sub-elements of the hierarchy, one is able to prioritize potential outcomes. The comparisons can be executed with actual quantitative data or using human judgment. The utility of AHP is in its ability to synthesize human judgment with quantitative metrics in an organized method to prioritize choices across multi-dimensional, complex problems.

The benefit of IRIS is that it takes a large number of decision parameters into account, capitalizing on the experience, expertise, and skills of the airport management team, and synthesizes them into a defensible ranking of options. These options are supported with numerical scores that can then be used in the capital planning process. They are also useful as support material when presenting funding recommendations to decision makers.

## Getting Started

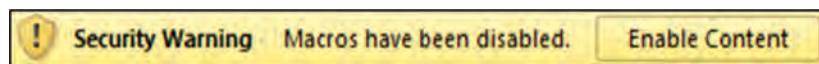
Before starting, the following is a list of information you should compile and have ready before running the IRIS tool:

- Descriptions of IROPS events to consider, for example:
  - Event 1: International widebody aircraft diverted to airport
  - Event 2: Extended tarmac delays due to ice on aprons

- Event 3: Power outage as result of a substation failure
- Descriptions of mitigations to be considered for each IROPS event, for example:
  - Event 3: Purchase 3x 2,000 kW emergency generator
- Estimated initial investment cost for each mitigation
- Estimated annual recurring cost for each mitigation
- Lifecycle duration of the IROPS investment business planning
- Cost escalation rate for each mitigation (or use default rate of 1.9%)

IRIS requires no special software other than Microsoft Excel, version 2007 or later. To start IRIS, right click on the file that contains the model (e.g., *ACRP 10-14 IRIS Tool.xlsm*) and select “Open” (or double click on the file name to begin the program). IRIS is optimized to display on screens with a resolution of 1024x768 pixels or greater.

IRIS requires an Excel function known as “macros” in order to function properly; ensure that macros are enabled when using IRIS. The process for enabling macros depends on the version of Excel in use, but usually involves a pop-up message with an “Enable Macros” or “Enable Content” button that should be selected (see Figure B.2, from Excel 2010). If no warning appears, macros are enabled.



**Figure B.2.** Macro security warning (Excel 2010 shown).

The main user interface that is displayed when IRIS is first opened is shown in Figure B.3. IRIS uses a series of five wizards to collect user input and perform its calculations. The main user interface is both a visual guide to the five wizards and a reminder showing the current step on which the user is working; an arrow points to the recommended next step. Items that are grayed out have been completed (if accompanied by a red check mark). If the step is grayed out but no red check mark is present, an intermediate step has not been completed and is required to move to the next step.

**B-4** Being Prepared for IROPS: A Business-Planning and Decision-Making Approach

**Figure B.3.** Main IRIS user interface.

The five wizards must be completed in the order shown, but once a wizard has been completed, the user can return to it at any time in order to make changes. To return to a previously completed wizard, simply click on the appropriate step. The five wizards that make up IRIS are:

1. The portfolio wizard
2. The cost wizard
3. The comparisons wizard
4. The effectiveness wizard
5. The results wizard

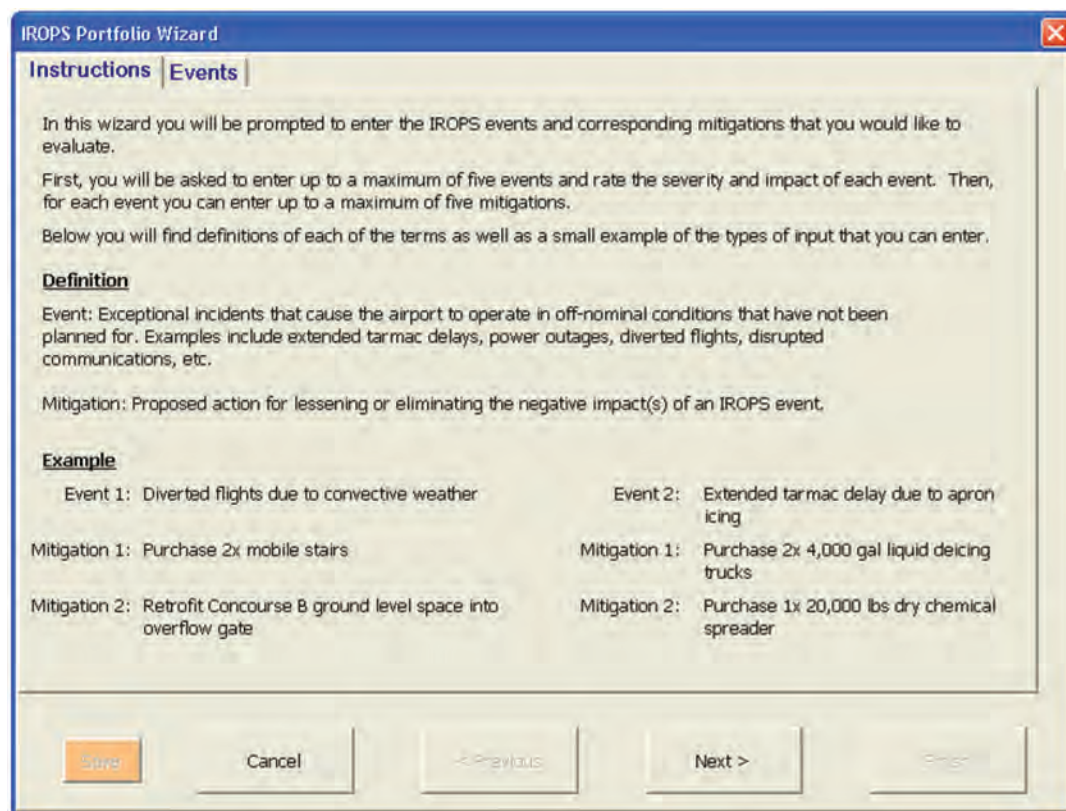
The image that illustrates each wizard will also launch it. Simply click on the image associated with the wizard and it will open. When IRIS is first run, only the portfolio wizard is active. You can only begin the next wizard when the previous wizard has been completed; wizards that cannot be selected have their images grayed out. The interface allows the user to go back and edit information entered into previously completed wizards. Note: Returning to edit a previously completed wizard may require you to make changes in successive wizards before continuing. For example, adding a new mitigation in the portfolio wizard would require that new cost information for that mitigation would need to be entered using the cost wizard.

Pressing the “Quick Reference” button will display the quick reference guide as a PDF document. Pressing the “Start Over” button will clear out all the information that has already been recorded. Note that all user entries are lost when “Start Over” is pressed.

Each wizard contains a “Save” button that can be used to save any partial progress made within the wizard, by saving the Excel file. After pressing this button, you can cancel out of the wizard and any information that is already entered will remain when you return to the wizard again. Pressing the “Save” button will also allow you to move forward to the next tab in the wizard (where applicable) even if you have not completed all of the current tab. However, a wizard will not allow you to press the “Finish” button with an incomplete tab. Note that IRIS also supports the file-saving functions embedded in Microsoft Excel (under the “File” menu). These can be used, for example, for making copies of an IRIS workbook.

## Portfolio Wizard

The first wizard is used to define the investment portfolio. Click on the “Portfolio” image to start the wizard; the IRIS software supports the consideration of up to five events in each run. The first window to pop up when the portfolio wizard is started contains the instructions for completing this wizard (see Figure B.4). Once you have read and understood the instructions, click the “Next” button to open the “Events” tab (see Figure B.5).



**Figure B.4.** Instructions tab for portfolio wizard.

**B-6** Being Prepared for IROPS: A Business-Planning and Decision-Making Approach

**Figure B.5.** *Events tab for portfolio wizard.*

The “Events” tab includes an optional field with a “Save File As” button to be used for specifying a file name. This saves the file under the name that is entered. This then becomes the file name that is used each time the “Save” button is activated in any wizard in order to save partial progress. Note that the file extension used for IRIS workbooks is “.xlsm”, where “.xls” indicates Excel and the “m” indicates that the file is an Excel application using macros. The default file name will be shown, but this can be changed by the user to any file name that is supported by Microsoft Excel. Note: If the file is not renamed when IRIS is first used, then if the “Save” button is used later anywhere else in IRIS, the original blank IRIS tool will be overwritten (if this occurs, the user can use the “Start Over” button on the main interface or, alternatively, reinstall a clean copy of IRIS).

The “Events” tab is also where the lifecycle duration is specified. The lifecycle is usually tied to the expected duration of the initiation (e.g., 10 years for a vehicle). Note: Since the rankings are based on total lifecycle benefits and costs, IRIS forces this value to be the same for all mitigations for all events. This is to ensure that comparisons between mitigations are not biased by having different lifecycles for each one. The lifecycle should include recurring costs representing replacement or refurbishment costs for mitigation alternatives with service lives shorter than the investment planning lifecycle. This may occur if a mitigation alternative with a short lifecycle is compared to one with a longer lifecycle in the same portfolio of IROPS events and mitigations. This is important to ensure that the results for all mitigation alternatives in the portfolio are comparable.

Next, enter the number of distinct IROPS events you would like to evaluate. Events refer to the situations that cause the IROPS-related problems that you would like to solve. Some examples might be Extended Tarmac Delay, Power Outage, Diverted International Flights, Disrupted Communications, etc. Press “OK” when done, which creates fields for collecting information about each event (see Figure B.6).

The screenshot shows the 'IROPS Portfolio Wizard - Events' window. It has two tabs: 'Instructions' and 'Events'. The 'Events' tab is active. The window contains the following elements:

- File name:** A text box containing 'ACMP 10.14.015 Tool Configuration.xlsx' and a 'Save File As' button.
- Lifecycle for IROPS investment planning:** A text box with '10' and a dropdown for 'years'.
- How many events would you like to evaluate?:** A text box with '2' and an 'OK' button.
- Event Data Table:**

	Description	Likelihood	Severity
Event #1:	Diverted flights due to convective weather	Probable	Major
Event #2:	Extended tarmac delay due to apron icing	Remote	Severe
- Buttons:** 'Create/Update Event Tab(s)' at the bottom center, and a footer bar with 'Save', 'Cancel', '< Previous', 'Next >', and 'Finish'.

**Figure B.6.** Adding events.

The information that must be entered for each IROPS event under consideration includes:

**Description:** The name or identifying characteristics of the event. Example: “International widebody aircraft diverted to airport.”

**B-8** Being Prepared for IROPS: A Business-Planning and Decision-Making Approach

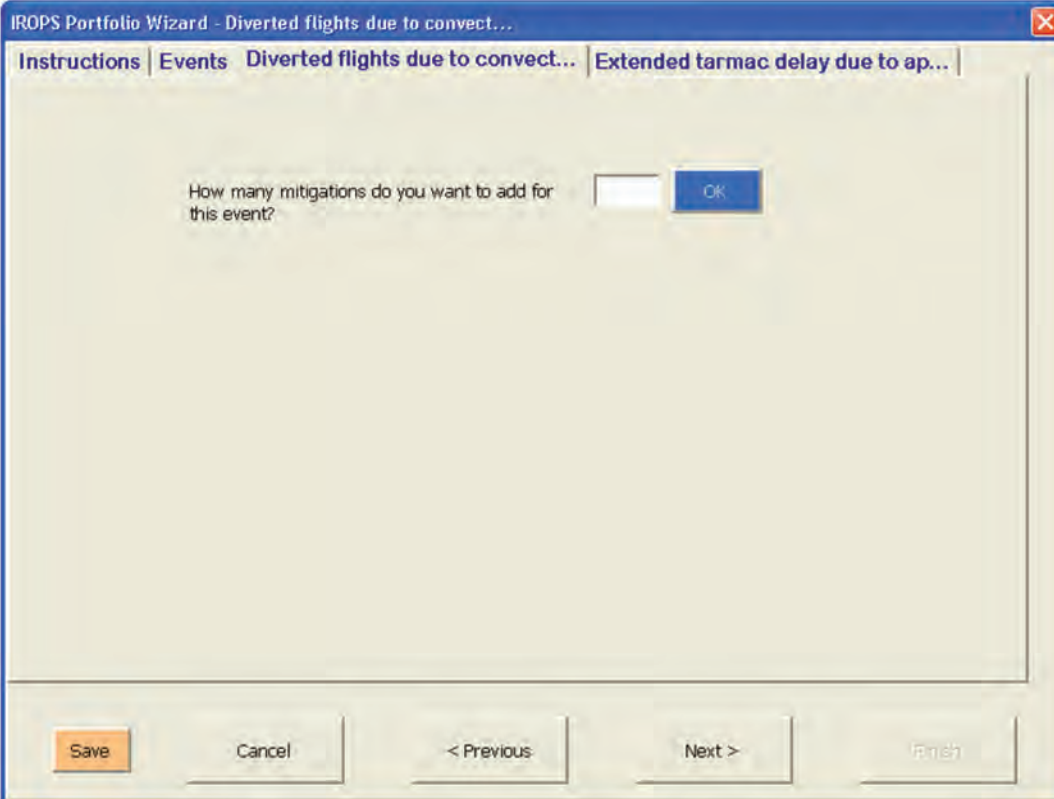
**Likelihood:** Enter your best estimate of the probability that each event might occur at your airport. The options are:

- Extremely Improbable
- Extremely Remote
- Remote
- Probable
- Frequent

**Severity:** Enter your best estimate of the magnitude of the impact that the occurrence of each event would have on your airport operations. The options are:

- Minimal
- Minor
- Major
- Severe
- Catastrophic

Once this information has been input for each event, click on the “Create/Update Event Tab(s)” button. This opens the interface for entering the mitigation information for each event. A new tab will be created for each event (see Figure B.7). Select the tab for the first event and enter the required information, then move on to the next tab by clicking on the “Next” button. For each event, enter the number of mitigations for that event that you would like to evaluate using IRIS.



The screenshot shows a Windows-style dialog box titled "IROPS Portfolio Wizard - Diverted flights due to convect...". It has four tabs: "Instructions", "Events", "Diverted flights due to convect...", and "Extended tarmac delay due to ap...". The "Diverted flights due to convect..." tab is active. Inside the dialog, the text "How many mitigations do you want to add for this event?" is followed by a small text input field and a blue "OK" button. At the bottom of the dialog, there are five buttons: "Save" (orange), "Cancel", "< Previous", "Next >", and "Finish".

**Figure B.7.** *Mitigation tabs for each IROPS event.*

Mitigations refer to the potential solutions for the problems identified within an event. Some examples are “Purchase additional mobile stairs” or “Construct a ground-level gate in Terminal B”. The combination of the specific IROPS events and associated mitigations make up the investment portfolio. For each event, a maximum number of five mitigations can be specified. This means IRIS can consider investment portfolios of up to 25 mitigations (a maximum of five mitigations for each of a maximum of five IROPS events). Press “OK” when done. At this point, fields appear for the purpose of collecting data for the mitigations under consideration (see Figure B.8).

**B-10** Being Prepared for IROPS: A Business-Planning and Decision-Making Approach

IROPS Portfolio Wizard - Diverted flights due to connect...

Instructions | Events | Diverted flights due to connect... | Extended tarmac delay due to ap...

How many mitigations do you want to add for this event?

Mitigation #1:

Mitigation #2:

**Figure B.8.** Adding mitigation descriptions.

In the new text boxes that are created, enter a description for each mitigation option to be considered. Press “Next” to continue to the tab for the next event. When descriptions have been completed for each event, press the “Finish” button to complete the portfolio wizard.

Note that after the completion of each wizard, IRIS validates the data for errors. If there are no errors in the input data, IRIS will return to the main interface, where the next wizard can be selected. Otherwise a message will appear, describing the error in the input data. Correct the data and complete the wizard to move on to the main interface.

### Cost Wizard

Clicking on the cost wizard button brings up a window that allows you to enter the estimated costs for each mitigation option in the portfolio (see Figure B.9). A tab is created for each event, starting with the first event created in the portfolio wizard. On each tab, there is a column for each mitigation entered when defining the portfolio in the portfolio wizard.

**Figure B.9.** Cost wizard.

The cost wizard is used to enter the best estimates available of the initial and recurring costs associated with each mitigation option. The required entries are:

**Initial investment cost:** Enter the estimated initial investment cost for each mitigation option. This could be construction costs (total costs, including design, permitting, etc.), acquisition costs, or, if the mitigation option is a staff effort such as preparation of a planning document, the cost of the associated labor hours. Depending on how the airport accounts for federal and other external funding, it is possible to take into account only the local share of project costs.

**Recurring cost:** Enter the average estimated costs that recur each year. This typically includes recurring costs for operations and maintenance (O&M). It may also include replacement or major refurbishment costs for investments with service lives shorter than the lifecycle duration. For example, consider an investment portfolio with a 10-year lifecycle that includes an information technology (IT) system with a 5-year service life. In this case, a replacement or refurbishment cost should be entered as the annual recurring cost, which can be estimated by spreading out the associated costs over each year in the lifecycle.

**Lifecycle duration:** This is the number of years to consider as the economic lifecycle of the investment analysis that was previously entered in the portfolio wizard.

**Escalation rate:** Enter the cost escalation rate as an estimated annual percentage growth in cost. An escalation rate of 1.9% will be used by default unless changed by the user.

**B-12** Being Prepared for IROPS: A Business-Planning and Decision-Making Approach

After entering data for one event, press “Next” to go to the next tab. When the cost information has been input for all mitigations and all events, press the “Finish” button to complete the cost wizard. If there are no errors in the input data, IRIS will return to the main interface. Otherwise a message will appear describing any errors in the input data.

### Comparisons Wizard

The purpose of the comparisons wizard is to elicit stakeholder preferences. For example, some airports may place more emphasis on funding availability as a criterion than other airports. The criteria are predefined (see Table B.1), but by conducting the pairwise comparisons, IRIS can quantify the relative importance of each criterion. Criteria that matter a great deal to the airport operator and its stakeholders will carry more weight in ranking the portfolio than criteria judged to be less important. The criteria take into account strategic and tactical challenges to implementing a specific IROPS mitigation initiative. The comparisons are also used to estimate the relative importance of potential benefits to airlines, passengers, and airport and tenant employees. The user interface for the pairwise comparisons process is shown in Figure B.10.

**Figure B.10.** Comparisons wizard.

**Table B.1. Definitions of IROPS mitigation effectiveness criteria.**

<b>Evaluation Criteria</b>	<b>Description</b>
<b>Strategic Challenges</b>	
Airport Master Plan Alignment	How well does the mitigation initiative align with the current airport master plan? Was it already considered in the capital plan? Is it a completely new concept?
Funding Availability	How accessible will funding be for this initiative? Does it qualify for a federal grant, PFC funding, PFC-backed bonds or other public funding? Airport-generated funds? Does this create a significant ongoing operational expense to the airport?
Stakeholder Coordination	How many stakeholders must be involved for this initiative? What level of coordination is required across different interested parties? What are the potential related complications? Impact on rates and charges? Airline use agreement?
Implementation Timeline	How long will the initiative take to procure/implement?
<b>User Benefits</b>	
Reduction in Airline Impact	How will this mitigation initiative reduce disruption to airlines in terms of time? Consider flights delayed, missed connections, crew scheduling, and extended tarmac delays.
Reduction in Traveler Delay	How will this mitigation initiative reduce delay experienced by travelers? Consider the value of the travelers' time, missed connections, and baggage lost.
Traveler Comfort	An evaluation of the level of comfort that can be provided to travelers during the IROPS event. Consider access to food, water, bathrooms, cots, telephone, Internet, airport/airline information, onsite overnight accommodations. Consider impacts on special needs travelers and the mobility impaired.
Improvement in Airport Operations	How does the mitigation strategy impact the work conditions for airport staff during IROPS events?
<b>Tactical Complexity</b>	
Disruption Level During Implementation	What level of disruption will this mitigation initiative cause to normal airport operations when it is in effect? [Note: This should <b>not</b> include disruption associated with the acquisition/construction of the alternative, for example temporary disruptions due to construction activity.]
Execution Response Time	How quickly can this contingency initiative be executed in order to address the IROPS event?
Policy & Regulatory Compliance Difficulty	How difficult will it be to maintain policy and regulatory compliance during the execution of the contingency initiative? Consider security, Federal Aviation Regulations Part 139, safety, etc.

**B-14** Being Prepared for IROPS: A Business-Planning and Decision-Making Approach

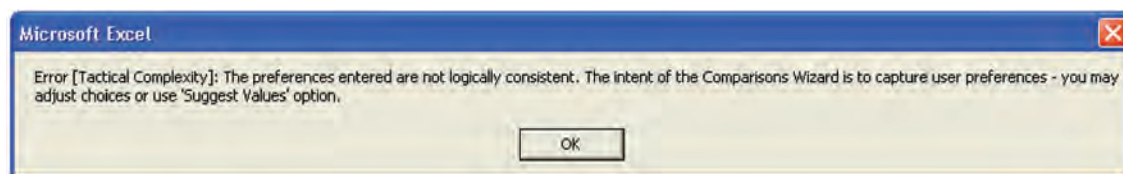
At the top of the window, there are four tabs: “Main Categories,” “Strategic Challenges,” “User Benefits,” and “Tactical Complexity.” The first tab, labeled “Main Categories,” is used to establish a high-level comparison of the three main categories against each other (i.e., strategic challenges vs. user benefits vs. tactical complexity). Each of the last three tabs represents a category of stakeholder considerations. Within each, several criteria are compared against each other. Each pair of comparisons is represented by a row as shown in Figure B.10.

For each pairing in the comparisons wizard, select the criterion that is more important to the airport and its stakeholders, by clicking on that criterion’s radio button. If both criteria are judged to be of equal importance, select “They are equally important.” After making the selection, a text box will appear asking “How much more?” Enter a number between 2 and 9, with the higher indicating greater relative importance. The values do not need to be integers; fractional values such as “2.5” and “5.75” are also supported. Table B.2 provides a scale that can be used to interpret these numerical scores.

**Table B.2. Rating scale for pairwise comparisons.**

<b>Intensity of Importance</b>	<b>Definition</b>	<b>Explanation</b>
1	Equal importance	Two elements contribute equally to the objective
3	Moderate importance	Experience and judgment moderately favor one element over another
5	Strong importance	Experience and judgment strongly favor one element over another
7	Very strong importance	One element is favored very strongly over another; its dominance is demonstrated in practice
9	Extreme importance	The evidence favoring one element over another is of the highest possible order of affirmation
Note: Intensities of 2, 4, 6, and 8 can be used to express intermediate values. Intensities of 1.1, 1.2, 1.3, etc., can be used for elements that are very close in importance.		

For the comparisons to be meaningful, they must be internally consistent. Stated preferences must be transitive (that is, if you indicate that you prefer A to B and also indicate that you prefer B to C, then it must be true that you prefer A to C). Also, the relative importance given to the criteria should not be contradictory (for example, saying A is extremely more important than B and that B is of equal importance to C, but also saying that A is only moderately more important than C). Since the criteria comparisons rely on human judgment, it is possible that the user could provide input that violates these principles. Once all inputs have been entered, the comparisons wizard checks for transitivity violations and makes sure the relative importance measures are consistent up to a certain threshold. If a problem is detected, a dialog box will pop up identifying the issue and the tab where the issue occurs. An example of such a message is shown in Figure B.11.



**Figure B.11.** *Message box indicating an error in comparison input.*

To fix the error, it is recommended that you review the relevant tab to locate the inconsistency and then adjust the comparisons and numerical scores manually as needed. However, IRIS does include a “Suggest Values” feature that automatically adjusts the current scores to make them logically consistent. Although this process will return consistent values, the result may not accurately capture user preferences so it is suggested that this feature only be used as a last resort.

At any stage the “Show Comparison Scale” button on the right side of the window can be pressed to display the numerical scale used to judge relative importance. Clicking on the “Show Criteria Descriptions” button will display the criteria definitions. Clicking on the “Clear All Values” button will erase all of the information you have already input into the comparisons wizard. This is used as an option to start over.

After the comparisons have been entered for one category, click the “Next” button to move onto the next category. Once all pairs have been evaluated, press the “Finish” button to complete the comparisons wizard. If there are no errors in the input data, IRIS will return to the main interface. Otherwise a message will appear, describing any errors in the input data.

## **Effectiveness Wizard**

The effectiveness wizard displays a window for estimating the relative effectiveness of each mitigation initiative (see Figure B.12). The first tab displayed shows the mitigation alternatives entered for the first event created in the portfolio wizard. Each column is associated with a specific mitigation. The rows correspond to the criteria arranged under four main categories used in the comparisons wizard. For each criterion, IRIS asks a question that polls the user for a best estimate of the effectiveness of the mitigation initiative. For example, the first question under “Strategic Challenges” is “How well does this mitigation initiative align with the current Airport Master Plan?” For each question, select the response that you judge to be most accurate for the mitigation initiative in question, using the drop-down menu. Note that the choices in the menu vary from question to question, to ensure that the possible answers match the question being asked.

When completing these subjective evaluations, it is important to consider the full spectrum of choices in the scale. One approach is to consider the scores as being relative to the solutions being evaluated. In this scenario, the best solution should get the highest score and the worst should get the lowest score. If the subjective evaluations are all near the “average” score then there is a risk that cost becomes the only real driver in ranking the IROPS mitigation alternatives.

**B-16** Being Prepared for IROPS: A Business-Planning and Decision-Making Approach

**IROPS Effectiveness Wizard**

Diverted flights due to connect... | Extended tarmac delay due to ap...

**Strategic Challenges**

1. How well does this mitigation initiative align with the current airport master plan?  
e.g., Was it already considered in the capital plan?

2. How accessible will funding be for this initiative?  
e.g., Does it qualify for a federal grant, PFC funding, PFC backed bonds or other public funding?

3. How much stakeholder coordination is required for this initiative?  
e.g., What level of coordination is required?

4. How long will this mitigation initiative take to procure/ implement?

**User Benefits**

5. How will this mitigation initiative reduce disruption to airlines in terms of time?  
e.g., Flights delayed, connectors missed, crew scheduling

6. How will this mitigation initiative reduce disruption to travelers in terms of delay?  
e.g., Value of travelers' time, missed connections, baggage lost

7. How comfortable will travelers be during the IROPS event?  
e.g., Access to food/water/bathrooms/accommodations/telephone/internet

8. How does the mitigation initiative impact work conditions for airport staff and tenant employees during the IROPS event?

**Tactical Complexity**

9. What level of disruption will this mitigation initiative cause to normal airport operations?

10. How quickly can this mitigation initiative be executed in order to address the IROPS event?

11. How difficult will it be to maintain policy and regulatory compliance during the execution of this mitigation initiative?  
(Security, FAR Part 135, ADA, safety)

Save Cancel Previous Next > Finish

**Figure B.12.** *Effectiveness wizard.*

When the evaluations for the first event are complete, press “Next” to continue to the next event. When the estimated effectiveness has been entered for all mitigation initiatives, press the “Finish” button to complete the effectiveness wizard. If there are no errors in the input data, IRIS will return to the main interface. Otherwise a message will appear, describing any errors in the input data.

## Results Wizard

Once the first four wizards have been completed and all necessary inputs have been entered, the results wizard becomes available. When selecting this wizard, a pop-up window appears prompting for a name and description for the report that will be generated once this wizard has been completed (see Figure B.13). Note: The report name can be a maximum of 17 characters and must conform to Microsoft Excel naming conventions. The description of the report is optional, but can be useful if, for example, the tool is run several times in succession to evaluate a number of “what if” scenarios. Pressing the “OK” button will generate the reports. This can take a couple of seconds, during which a number of reports are created.



**Figure B.13.** Running the results wizard.

IRIS generates five reports summarizing information from the user-defined portfolio. The tab that is active after the wizard has completed the results is a cover sheet that allows you to navigate through these five reports (see Figure B.14). You can also navigate the reports using the spreadsheet tabs for each report worksheet. The following reports are produced by IRIS:

**Cover:** Provides a cover sheet for the report. Logos and headers can be added.

**Summary:** Ranks mitigation efforts for all events weighted by impact, effectiveness, benefit, and cost. This report is discussed in more detail below.

**Portfolio:** Report containing information about events and the available mitigations along with their description, likelihood and severity of each mitigation.

**Cost:** Cost information related to investment cost, recurring cost, lifecycle (years), rate, and total cost for each mitigation option.

**Criteria:** User-defined priorities derived from comparisons done for strategic challenges, tactical complexity and user benefits.

**Effect:** User-defined input related to questions posed to the user in the effectiveness portion of the tool.

**B-18** Being Prepared for IROPS: A Business-Planning and Decision-Making Approach

IRIS Tool Analysis Report COVER SHEET	
Report Name:	Demo
Description:	IRIS Demonstration
Created:	9/13/13 10:50 AM
	Description
<a href="#">Demo Summary</a>	Ranks mitigation efforts for all events weighted on impact, cost and benefit impact scores
<a href="#">Demo Portfolio</a>	Report containing information about events and the available mitigations along with their description, likelihood and severity of each mitigation
<a href="#">Demo Cost</a>	Cost information related to Investment Cost, Recurring Cost, Lifecycle (yrs), Rate and total cost for each mitigation option
<a href="#">Demo Criteria</a>	User defined priorities derived from comparisons done for Strategic, tactical complexity and user benefits
<a href="#">Demo Effect</a>	User defined input related to questions posed to user in effectiveness portion of IRIS
<input type="button" value="Print Report"/> <input type="button" value="Save As..."/> <input type="button" value="Modify Inputs..."/>	

**Figure B.14.** Cover sheet to navigate IRIS reports.

The cover sheet also contains buttons for printing, saving, and modifying inputs. Pressing the “Print Report” button will print only the six tabs associated with the six reports produced by IRIS referenced above. Blank tables in the spreadsheet, which are generated when fewer than five IROPS events are defined in the portfolio, are not printed.

The “Modify Inputs...” button will return you to the IRIS tool so that you can make any revisions or updates to the input data. Note: pressing the “Modify Inputs...” button will delete the IRIS-generated report tabs and any tabs added by the user, so it is important to save any data you want to keep before proceeding. A warning message to this effect is displayed when selecting the “Modify Inputs...” feature. This functionality is useful for producing “what if” scenarios. By saving the current output and then returning to IRIS to modify one or more inputs, results across several different scenarios can be compared.

The summary report is the most relevant report for most users, and is the only one described in detail in this User Guide. An example generated from a fictional case is presented in Figure B.15. The summary report presents the mitigation portfolio with the alternatives ranked from most cost beneficial to least cost beneficial, based on the recommendations computed by IRIS. Note: The IROPS mitigations are ranked based on the Combined score, which is the ratio of the Benefit score to the Cost score. The higher this ratio, the more value, in terms of benefits, is expected for the funds invested in the mitigation in question. Note: Unlike a true benefit-cost ratio, the Combined score computed by IRIS can only be used to make relative comparisons across mitigation alternatives. While a benefit-cost ratio that is greater than one indicates that the economic value of the benefits outweigh total costs, this is not the case for the Combined score computed by IRIS. The Combined score can be used to rank alternatives to determine which provides the most value. It can also be used to judge how close alternatives are to each other. It cannot, however, be used to judge whether the benefits of an IROPS mitigation alternative outweigh the costs, since IRIS does not attempt to monetize benefits in dollar terms.

**Rank:** Overall rank for the mitigation after the scores for benefit and cost have been combined

**Benefit:** Combination of the Impact and Effectiveness scores; the higher this score, the more benefit the mitigation alternative is expected to bring to the airport stakeholders

**Combined:** A computed score that takes into account both the Cost score and the Benefit score to create an estimate of the overall benefit-cost value

Rank	Portfolio		Impact x Effectiveness = Benefit			Cost		Combined	
	Event	Mitigation	Impact Score	Effectiveness Score	Benefit Score	Score	Lifecycle (\$)	Score	Percent
1	Diverted flights due to convective weather	Purchase 2x mobile stairs	0.500	0.463	0.231	0.033	\$221,800	6.969	62.0%
2	Diverted flights due to convective weather	Retrofit Concourse B ground level space int	0.500	0.537	0.269	0.088	\$586,595	3.062	27.3%
3	Extended tarmac delay due to apron icing	Purchase 1x 20,000 lbs dry chemical spreader	0.500	0.518	0.259	0.345	\$2,304,959	0.751	6.7%
4	Extended tarmac delay due to apron icing	Purchase 2x 4,000 gal liquid deicing trucks	0.500	0.482	0.241	0.534	\$3,569,938	0.451	4.0%

**Portfolio:** Description of each entry in the mitigation portfolio, showing the associated IROPS event and the proposed mitigations

**Cost:** Two views of the mitigation costs: A relative Cost score and the dollar value of the lifecycle costs of each mitigation initiative

**Figure B.15.** Summary report output from fictional example.

The table produced in the summary report has five main column groups, some of which have sub-columns to break down the information further. The main column groups are:

**Rank:** This is the overall rank for the mitigation after the scores for benefit and cost have been combined. The mitigation that is ranked number one is the one determined to be the most cost beneficial by IRIS, given the inputs provided by the user.

**Portfolio:** This set of columns describes each entry in the mitigation portfolio, showing the associated IROPS event and the proposed mitigations.

**Benefit:** This set of columns lists the Benefit score for the mitigation alternative. The higher this score, the more benefit the mitigation alternative is expected to bring to the airport stakeholders. However, the Benefit score alone does not take into account the cost of the mitigation. Therefore, the mitigation alternative with the highest Benefit score does not necessarily have the highest overall rank.

The Benefit score combines the Impact and Effectiveness scores, by multiplying the two. These two scores, in turn are defined as follows:

**Impact:** The Impact score determines how disruptive the IROPS event would be. It is computed based on the severity of the event, as well as the likelihood of the event occurring. Note: If only one IROPS event is defined in the portfolio, this score will be 1.000 for all mitigation alternatives.

**Effectiveness:** The Effectiveness score measures how effective the mitigation alternative is in providing user benefits while addressing tactical and strategic challenges. It is computed based on the evaluations entered in the effectiveness wizard. The effectiveness score is weighted by the results of the comparisons wizard, in order to take into account stakeholder preferences and priorities.

**Cost:** This set of columns presents two views of the mitigation costs: A relative Cost score and the dollar value of the lifecycle costs of each mitigation initiative. The higher the Cost score, the more expensive the mitigation initiative is over the course of the planning lifecycle.

**Combined:** These columns show a computed score that takes into account both the Cost score and the Benefit score to create an estimate of the overall benefit-cost value. The score is calculated as the ratio between combined strategic, user and tactical benefits derived from a particular mitigation to its relative cost. The Combined score determines the ranking of the mitigations. This is represented both as a numerical score (in the “Score” column) and the relative magnitude of that score, expressed as a percentage of the combined score across all initiatives (in the “Percent” column). The percentage score can be useful to quickly evaluate whether certain alternatives rank closely to each other or not.

The remaining reports present the user-input data underlying these score calculations. They document the user inputs entered in each of the four input wizards (i.e., the portfolio, cost, comparisons, and effectiveness wizards). Each report is given a unique identifier, which is created by combining the report name provided by the user and a one-word descriptor. For example, if the user names the report “CIP2013”, then the Portfolio report will be identified as “CIP2013\_Portfolio.” The remaining reports are:

**Portfolio report:** Includes the input from the portfolio wizard. Includes the IROPS events and each mitigation alternative in the portfolio. For each mitigation alternative, the specified likelihood and severity are shown.

**Cost report:** Includes the initial investment cost for each mitigation alternative, as well as the annual recurring cost, lifecycle duration in years, and annual cost escalation (expressed as a percentage rate). Note that the lifecycle duration is specified for the entire portfolio and is therefore always the same for all mitigation alternatives. The final column shows the total lifecycle cost, which is computed from the other cost inputs.

**Criteria report:** Includes the pairwise comparison for each criterion in the three categories “Strategic Challenges,” “User Benefits,” and “Tactical Complexity.” The comparison scale is shown for reference. For each pair, the criterion judged to be more important is indicated by a score greater than 1, as specified by the user. Criteria judged to be equally important are both shown with a score of 1.

**Effectiveness report:** Includes the level of effectiveness of each mitigation alternative, for each criterion evaluated by the user in the effectiveness wizard. The Effectiveness ratings are arranged in separate tables for each IROPS event in the portfolio.

### **Printing, Exporting, and Saving**

IRIS uses macros and therefore uses the “.xlsm” file extension, but is in all other respects a normal Microsoft Excel spreadsheet. The output tables described above can be copied into other spreadsheets, Microsoft Word, or other documents, in order to create reports, using the copy and paste functionality in all Microsoft Office applications. The output and input tables can be printed or converted into the PDF file format, as long as a PDF driver is available on the system (Microsoft Office 2010 and later versions include a PDF driver). In other words, the full copy and paste, file manipulation, and input/output services supported by Microsoft Office and the Windows operating system are also supported by IRIS. The file can also be saved to be opened at a later time or in order to be forwarded by e-mail message, or otherwise distributed and copied.



## APPENDIX C

# Sample IROPS Investment Portfolio

For training and testing purposes, a sample investment portfolio is shown here, along with the key inputs required for defining the portfolio in IRIS. Note that the sample portfolio is fictitious: The mitigation initiatives and associated costs are intended to represent plausible choices, but are not based on a real-world example.

## Portfolio Definition

**Lifecycle for IROPS investment planning:** 10 years

**How many events would you like to evaluate?** 2

### *IROPS Event 1*

**Event:** Diverted flights due to convective weather

**Likelihood:** Probable

**Severity:** Major

**Table C.1. Inputs for sample IROPS Event 1.**

Mitigation initiatives	Initial Cost	Recurring Cost
Purchase 2x mobile stairs	\$200,000	\$2,000
Retrofit Concourse B ground-level space into overflow gate	\$325,000	\$24,000

### *IROPS Event 2*

**Event:** Extended tarmac delay due to apron icing

**Likelihood:** Remote

**Severity:** Severe

**Table C.2. Inputs for sample IROPS Event 2.**

Mitigation initiatives	Initial Cost	Recurring Cost
Purchase 2x 4,000 gal. liquid deicing trucks	\$300,000	\$300,000
Purchase 1x 20,000 lb. dry chemical spreader	\$125,000	\$200,000

*Abbreviations and acronyms used without definitions in TRB publications:*

A4A	Airlines for America
AAAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI-NA	Airports Council International-North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation